교육학석사학위논문

A Comparative Study of Middle School Statistics Curriculum and Textbook in Korea and China

한국과 중국의 중학교 통계 교육과정 비교 연구

2019년 8월

서울대학교 대학원

수학교육과

LIU, SICHANG

A Comparative Study of Middle School Statistics Curriculum and Textbook in Korea and China

지도교수 유 연 주

이 논문을 교육학석사 학위논문으로 제출함

2019년 7월

서울대학교 대학원

수학교육과

LIU, SICHANG

LIU, SICHANG의 석사 학위논문을 인준함

2019년 7월

위 원 장 권 오 남

부 위 원 장 이 경 화

위 원 유 연 주

Abstract

A Comparative Study of Middle School Statistics Curriculum and Textbook in Korea and China

LIU, SICHANG
The Graduate School of Mathematics Education
Seoul National University

This study is conducted to compare the middle school statistics education in Korea and China, summarize the similarities and differences on national mathematics curriculum, the mainstream textbooks from each country, and also explore the statistical investigation process embedded in the middle school education contents. For which purpose, this paper introduced the framework suggested by the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report as the criteria, and during the research, not only the national curriculum and textbook, but also the information provided by in-service teachers and other researchers from two countries are taken into consideration so that the comparison result from a more comprehensive perspective is achieved. And finally a general conclusion and advice extracted from the all the comparative researches on statistics education will be given.

In this paper, non-experimental qualitative studies are employed from two main perspectives, national curricula and textbooks in Korea and China, and having GAISE as a reference during the comparison. In the end, multidimensional

conclusions on statistics education in middle school with respect to the national curricula and different versions of textbooks aligned with the curricula are drawn: first, in Korean new national curriculum, some part of the statistics education seems divergent with the general objectives and key competencies, so does the edition of textbooks, while the statistical contents in the Chinese curriculum and textbooks shows better in consistence; second, aligned with the latest national curriculum, Korean new textbook contains a more complete statistical investigation process, but the main contents still focus more on calculation than Chinese textbook; third, by the framework in GAISE, statistics education in both Korea and China appear to show a lack of important components in the statistical investigative process, whereas the pure calculation catches too much attention. And hopefully the research results in this paper could make a contribution to the development of statistics education in both countries, especially the reforms of national curricula and textbooks related to the statistical domain which are undertaken constantly.

Keywords: Comparative Study, Statistics Education, National Curriculum, Middle School Textbook, GAISE

Student Number: 2017-26086

Acknowledgements

Thank you all.

Table of Contents

List of Tables

List of Figures

I. Introduction

1. Necessity and Goals

The acceleration of globalization requires the formulation of new national curriculum in each country to train internationalized talents, especially the curriculum in the domain of statistics, which is a newly developing component of the curriculum compared with other domains in mathematics. Ever since we entered the era of big data, the data handling strand has been taking larger proportion during the curriculum reformation period in many countries, while the reform is fulfilled with challenges due to the political, cultural and other social reasons in some relatively conservative countries. Many educators have confronted with setbacks during the innovation of statistics part in mathematics curriculum. Under the circumstances, practical researches, especially the comparative researches have served as an important reference in the reform. Every time the curriculum is revised, it is customary to introduce foreign cases for comparative study. Comparative educators are well placed to explore why some approaches to providing education have not met goals of equity or quality, and why others do meet these goals (Anne Hickling-Hudson, 2007). In this paper, a comparative research will be conducted from two aspects — national curriculum and textbooks.

As the medium of knowledge transmission, curriculum materials play a central role in teaching and learning, and differences across curricula can lead to differences in students' academic performance. The study of the curriculum is one

of the most important steps. It is necessary to analyze the characteristics of the target subject, discuss the basic curriculum issues, and clarify the knowledge boundaries and principles in this field. The study of curriculum setting can help the policy makers improve and reform the curriculum materials for guidance, and also support the educational practitioners to fully understand the development of mathematics curriculum and complete the didactical work.

The study on textbooks used in the classroom also has a significant relevance in the researches about curriculums. The textbook writing is supposed to be closely aligned with the national curriculum thus it could be seen as a solid reflection of the curriculum. Since almost the entire didactic process, including the subject and object's behaviors and facilities utilized during the process, is based on the content and instructions on the textbook used in the classes, through the exploring of textbook we can get a close look on the foundation of the didactic process. In this way, we can analyze and compare how the national curriculum is implemented in Korea and China.

Conducting the comparison between Korea and China could be seen as a meaningful and helpful research to both countries for several reasons. The connections between two countries are tight and multifold. Since they are close to each other geographically, historically, culturally, socially, politically, and in many other ways, Korea and China share some essential similarities in both civilizations. While the asynchronous development stages and processes of them generate many differences which might be used as substantial references to each

of the two countries in a proper way.

There are several aims of comparing secondary school mathematics curricula of statistics part in Korea and China. First aim is to supply assistance for the revision of middle school mathematics curriculum, textbooks or other teaching material, second aim is to serve as a reference for the development of national statistics education in each country.

2. Research Questions and General Framework

There are two main questions to be explored in this paper.

(1) Does the statistics curriculum meet the need of educating the statistical literacy for middle school students in Korea and China?

(2) What are the similarities and differences between the statistics education contents in Korean and Chinese middle school textbooks in terms of the content, sequence and the connection between them?

In this paper, the literature review in chapter II includes the knowledge concerning comparative study, curriculum, background of the national curriculum and relative papers and researches. To answer the research questions, national curricula and textbooks from two countries are not simply displayed and compared with each other, but need to be analyzed in compliance with some criteria, for which reason, Guidelines for Assessment and Instruction in Statistics Education Report (Franklin, 2005) is chosen in this paper to serve as such a criteria for the

analysis of education materials to be compliant with. The related information which needs to be acknowledged before the analysis and comparison research will be presented after the general literature review.

Besides, the more specific frameworks and research methods regarding each of the research questions will be given in chapter Ⅲ.

After this chapter, I will conduct the comparison study according to each of the two questions above, which are in chapter IV where the national curricula are analyzed in details and compared from different angles, and in chapter V where I will present and discuss the mainstream textbooks in Korea and China.

Lastly, conclusions and discussions for future study and the statistics education in two countries will be presented in the final chapter.

II. Literature Review

This chapter consists of two sections: the first one is a general review of relevant papers, researches and necessary information from other literatures, and the second one is concerning GAISE (Franklin, 2005), which will be the main criteria used for conducting the analysis and comparison research in this paper.

1. Comparative Study on Curriculum and Textbook Regarding Statistics Education

Statistical literacy is essential in our personal lives as consumers, citizens, and professionals. Statistics plays a role in our health and happiness. Sound statistical reasoning skills take a long time to develop. The surest way to help students attain the necessary skill level is to begin the statistics education process in the elementary grades and keep strengthening and expanding students' statistical thinking skills throughout the middle and high-school years (Franklin, 2005). The significance of statistical literacy that students have achieved before college has been realized by large numbers of educators worldwide and consequently the middle school statistics education are drawing more and more attention globally.

Regarding the comparative study of education, many people find not only that they that learn more about other cultures and societies but also that they learn more about their own (Mark BRAY, 2015). This was eloquently expressed by Sir Michael Sadler (1900) that "The practical value of studying, in a right spirit and with scholarly accuracy, the working of foreign systems of education is that it will result in our being better fitted to study and understand our own." In the book of

Comparative Education Research (Mark Bray, 2014), some historical perspectives and perspectives for the new century are given, as well as the classification of actors and purposes in comparative education, qualitative approaches to comparative education and comparing from different aspects. Many educators and organization have addressed goals, principles and theories in this field. Also quite many comparative researchers and students in this area have compared the system, policies, curricula, textbooks, exam items, social or cultural factors, etc. across the world. The comparative studies may be subdivided into (i) comparative pedagogy (classroom studies) and (ii) intra-educational and intra-cultural analysis, which investigate education by its various levels, and also systematically researches the historical, social, cultural, political, religious, economics and philosophical forces that partly determine and are determined by the character of education systems, and compares the resultant outcomes in two or more systems (Halls, 1990).

With respect to curriculum, this word "curriculum" originated from a Latin word which means "a race" or "the course of a race". By the nineteenth century, European universities routinely referred to their curriculum to describe both the complete course of study and particular courses and their content (Oxford English Dictionary, "Curriculum").

Concerned with interrelations and differences between the variant definitions, we can distinguish and compare the “intended curriculum”: that described in official documents carrying the status of policy; “tested curriculum”: the range of performance covered by the official tests; “implemented curriculum”: what is

actually taught in most classrooms; “achieved curriculum”, what most students actually learn (Burkhardt, 2014).

1. Study on Curriculum and Textbook in Korea and China Regarding Statistical Literacy

In Korea, many middle school textbooks are developed as aligned with the curriculum standards and the information provided and highlighted in the curriculum. The recent two reforms of the Korean national mathematics curriculum happened in 2009 and 2015. The general achievement objectives in the former Korean national curriculum in 2009 presented the achievement standards from three different ways, a, b and c (Appendix 1.4), and in the new curriculum in 2015, the standards are left with one version and more clearly displayed with an unique code for each component of the standard (Appendix 1.3). Compared with the former curriculum, the document format has been changed obviously in the new national curriculum, and with respect to the contents, the direction of the revised new mathematics curriculum could be summarized as: (a) Identification of mathematics curriculum competencies (b) Reducing the burden of learning too many contents (c) Emphasis on learner's affective side (d) Reconstruction of statistical contents centered on real life (e) Emphasis on the use of engineering tools (Ministry of Education).

Yoon, Lee and Kwon (2019) conducted a study on the relationship between core competencies and mathematical competencies and the tasks for mathematical

competencies in mathematics textbooks according to 2015 revised mathematics curriculum. One of the implications in this study is the necessity of the connection with core competencies and the focus on the most of characteristics of subject in the same time.

Paik (2014) conducted a comparative study on the statements of achievement standards in subject curriculum in Korea and U.S., focusing on the Korean 2009 revised science curriculum. Paik proposed five ways to improve statements of the subject achievement standards: “First, achievement standards should present the competencies students are expected to attain. Second, achievement standards should clearly identify the skill(s) and/or process(s) in each subject area. Third, achievement standards should present the connection between the knowledge and skills related to each subject. Fourth, the number of achievement standards must be limited by selecting the core ideas of the subject content. Finally, better structuring of subject content is needed to represent connections across core ideas in achievement standards”.

The curriculum is stipulated in the "Dictionary of Education" in China: Curriculum is the teaching subject of the school, which is mainly formulated by the competent departments of various types of schools. Chen (1989) believes that the so-called curriculum is the teaching subjects of various types of schools and the teaching hours of each subject. Wu (1984) defines the curriculum as the sum of the teaching subjects and their content, purpose, weight, scope and process to achieve the training objectives of all types of schools. Wang (2011) proposed that

curriculum setting is the key means to achieve the goal of talent training, and it is the main embodiment of the teaching content. In 2001, for the first time the Ministry of Education of China made it clear in the revised curriculum in 2001 that the "statistics and probability" knowledge should be introduced into the mathematics classroom teaching in primary and middle schools (Hak Ping Tam, 2014). While in 2005 professor Boju Jiang called for a halt to the implementation of the new mathematics curriculum (Lamet al. 2012). Professor Jiang pointed out the necessity to keep on checking the way that the curriculum reform has gone through, and constantly revise it (Yang, 2010). The "Compulsory Education Mathematics Curriculum Standards" promulgated in 2011.

Zhao (2016) compared the requirements of the 2001 new curriculum standards and the 2011 edition in "Statistics and Probability", as well as the old and new versions of textbooks and investigated the status quo of teachers and students. Zhao found most teachers were holding a positive attitude towards the changes, in particular, they thought the "Statistics and Probability" section is more logical and structured.

Huo (2011) compared the content of “Statistics and Probability” in Chinese and American primary textbooks, “PEP” and “California Edition”. Huo found that the content of PEP textbook was more difficult in depth but less in breadth compared than which of the California Edition, and two sets of textbooks were distinct hugely in course time, compiling style, structure, text features, etc.

Park and Leung (2006) compared the eighth-grade mathematics textbooks of

China, Japan and Korea on the one hand, and those of England and the United States on the other, to explore the implications for mathematics education in East Asia and the West. They found that textbooks in the West might help students realize how useful mathematics could be in their lives, but if the link between a mathematical concept and the corresponding real life situation was not made clear, students might not be able to completely grasp the mathematical concept. By contrast, the East Asian textbooks might succeed in conveying ideas in an economical way, but they often fail to motivate students to learn.

3. Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report

Guidelines for Assessment and Instruction in Statistics Education Report is endorsed by the American Statistical Association and could be freely shared for educational and classroom use (Franklin, 2005). Over the past quarter century, statistics has become a key component of the pre-K–12 mathematics curriculum. Advances in technology and modern methods of data analysis in the 1980s, coupled with the data richness of society in the information age, led to the development of curriculum materials geared toward introducing statistical concepts into the school curriculum as early as the elementary grades. This grassroots effort was given sanction by the National Council of Teachers of Mathematics (NCTM) when their influential document, Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989), included “Data

Analysis and Probability" as one of the five content strands. In recent years, many mathematics educators and statisticians have devoted large segments of their careers to improving statistics education materials and pedagogical techniques. GAISE has provided a framework and specific illustration of it, and the main objective of this is to provide a conceptual framework for K–12 statistics education (Franklin, 2005). The foundation for this framework is built upon the NCTM Principles and Standards for School Mathematics (2000). The NCTM Principles and Standards describes the statistics content strand as follows: Data Analysis and Probability Instructional programs from pre-kindergarten through grade 12 should enable all students to: (i) formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them; (ii) select and use appropriate statistical methods to analyze data; (iii) develop and evaluate inferences and predictions that are based on data; and (iv) understand and apply basic concepts of probability. The framework provided by GAISE (Franklin, 2005) is intended to complement the proposals by the NCTM Principles and Standards, not to replace them.

The framework suggested by GAISE (Franklin, 2005) is as follows:

Table 1 The framework in GAISE (Franklin, 2005)

Component	Level A	Level B	Level C
I. Formulate Question	Teachers pose questions of interests Questions are restricted to the classroom	Students begin to pose their own questions of interest Questions not restricted to the classroom	Students pose their own questions of interest Questions seek generalization
II. Collect Data	Census of classroom Simple experiment	Sample surveys; begin to use random selection Comparative experiment; begin to use random allocation	Sampling designs with random selection Experimental designs with randomization
III. Analyze Data	Display variability within a group Compare individual to individual Compare individual to group Beginning awareness of group to group Observe association between two variables	Quantify variability within a group Compare group to group in displays Acknowledge sampling error Some quantification of association; simple models for association	Measure variability within a group; measure variability between groups Compare group to group using displays and measures of variability Describe and quantify sampling error Quantification of association; fitting of models for association
IV. Interpret Results	No generalization beyond the classroom Note difference between two	Acknowledge that a sample may or may not be representative of the larger	Generalize from sample to population Aware of the effect of randomization

	individuals with different conditions Observe association in displays	population Note the difference between two groups with different conditions Aware of distinction between observational study and experiment Note differences in strength of association Basic interpretation of models for association Aware of the distinction between association and cause and effect	on the results of experiments Understand the difference between observational studies and experiments Interpret measures of strength of association Interpret models of association Distinguish between conclusions from association studies and experiments
Nature of Variability	Measurement variability Natural variability Induced variability	Sampling variability	Chance variability
Focus on Variability	Variability within a group	Variability within a group and variability between groups Covariability	Variability in model fitting

Table 1 shows the framework put forward by GAISE (Franklin, 2005). GAISE's framework provides a conceptual structure that enables us to observe a coherent picture of the overall statistics curriculum.

Statistical problem solving is an investigative process that involves four process components: formulate questions, collect data, analyze data and interpret results. The conceptual structure for statistics education is provided in the two-dimensional model shown in the framework in Table 1. One dimension is defined by the problem solving process components with the nature of the variability considered and how we focus on variability. The second dimension is comprised of the three developmental levels. Each of the first four rows describes a process component as it develops across the three levels and the fifth row indicates the nature of the variability. It is agreed that deeper and further the concepts are assumed at Level B than Level A. Checking the column from top to bottom, we can find a complete statistical investigation process at each of the three levels along with the nature of the variability suggested and defined by GAISE (Franklin, 2005).

This framework will serve as the main criteria to help to examine and compare statistics investigation process buried in the middle school curriculum and textbook in Korea and China. The analysis of national curricula and textbooks in two countries will be conducted in compliance with GAISE's framework separately in the following four chapters, and finally a conclusion combined with curriculum and textbook can be reached to reflect the middle school statistical education situation in a more comprehensive prospective.

III. Methods

1. Data Collection

The research data employed in this paper is collected from three aspects as follows.

(1) Gather statistical educational materials of the national mathematics curriculum in Korea and China.

The most recent national curriculum in Korea is released in 2015. The document is called Mathematics Curriculum Notification No. 2015-74 [Separate volume 8] (수학과 교육과정. 교육부 고시 제2015-74호 [별책 8], and it is published by the Ministry of Education in Korea. In this paper, most of the analysis of Korean national curriculum is according to this document (it will be noted as "Korean national curriculum ('15)" for short, or "Korean new national curriculum" for emphasis on the changes compared to the former curriculum). While the former one is published in 2009 (this version of curriculum will be abbreviated to Korean national curriculum ('09)), which will also be referred to for comparison study, called Mathematics Curriculum Notification No. 2011-361 [Separate volume 8] (수학과 교육과정. 교육과학기술부 고시 제2011-361호 [별책 8]), Unlike the one in 2015, Korean national curriculum ('09) is published by Ministry of Education, Science and Technology.

The current version of the Chinese Mathematics Curriculum Standards (CMCS, Ministry of Education 2011) was revised from an experimental version that was published in 2001 (Fuson and Li, 2014). The title may be slightly changed in different published versions, and I was given a book of Chinese national

curriculum standards, (Compulsory Education) Mathematics Curriculum Standards (2011 version). Ministry of Education of the People's Republic of China. Beijing Normal University Publishing Group. Beijing Normal University Publisher ((义务教育) 数学课程标准（2011年版）. 中华人民共和国教育部制定. 北京师范大学出版集团. 北京师范大学出版社), from an in-service teacher in Beijng in recent month, which will be used as the main material in this study.

(2) Gather different versions of textbooks in Korean and Chinese middle school.

In both countries, different sets of textbooks from various publishers are available, while I tried to choose one of the representative versions for this study. The Korean textbooks employed in this paper are published by the Donga Press and the Chinese textbooks are from the People's Education Press.

With respect to the Korean textbooks, first I will list several of the publishing firms who have published the textbooks aligned with the new curriculum: Donga Press, Chunjae Education, Sinsago Group, Kyohaksa Publishing, Visang Education, Jihaksa Publishing, Kumsung Publishing, Mirae N. The Korean textbooks analyzed in this paper are from one publisher called Donga Press (Woo Jungho, 2009 revision; Park Kyosik, 2015 revision). The edition of textbook from private publisher is guided by the Korea national curriculum, and the one corresponding to national mathematics curriculum ('09) (this version of textbook is abbreviated to "textbook ('09)" in the following) has been published and implemented for years, while the new version corresponding to the national

mathematics curriculum ('15) (this version of textbook is abbreviated to "textbook ('15)" in the following) has not been completely implemented, with textbooks for 7th grade and 8th grade already used in school, and the textbook for 9th grade in preparation. Therefore, I will analyze the textbook ('09) for 9th grade of Korea instead.

In China a variety of textbooks from different publishers are used all over the country. Here several of the publishing firms are listed: People's Education Press, Beijing Normal University Publishing House, Zhejiang Education Publishing House, Hunan Education Publishing House, East China Normal University Press, Phoenix Science Press, Shanghai Scientific & Technical Publishers, Hebei Education Publishing House, Shandong Education Press. The textbooks published by People's Education Press (abbreviated as PEP) will be analyzed and compared with the Korean textbooks. PEP is a large-scale professional publishing house affiliated to the Ministry of Education, and the PEP textbooks are well aligned with the national curriculum. The content of the textbook from PEP is relatively difficult, but the logical relationship between different knowledge components is explicitly stated compared to other textbooks. It is widely used in Beijing and some other places around the country. Also most comparative studies utilize the PEP textbook as the representative of Chinese textbook.

(3) Gather the information provided by in-service teachers and other research papers.

Students' ability to apply statistical methods is essential in the statistics

literacy. Thus the information regarding the real statistics classrooms provided by in-service teachers and other researches are employed in this paper. The teachers who offered the related information as testimonies are Miss Lee, a secondary math teacher of School A in Gyeonggi-do with seven years' experience of teaching, and Miss Lee, a middle school math teacher of School B in Seoul with five years' experience of teaching and Miss Liu, a middle school math teacher of School C in Beijing with 10 years' experience of teaching.

2. Analysis Methods

According to criteria given by Halls (1990), the comparative study in this paper could be classified as intra-educational analysis in two nations. The intended curriculum will be mainly demonstrated, compared and discussed using national curricula and textbooks from Korea and China, while the implemented curriculum will be taken into consideration with the information provided by in-service teachers and other researchers.

This research will analyze the collected data in the following ways:

(1) Understand and analyze the basic concepts and contents in the national mathematics curricula in two countries, especially focusing on objectives and standards within the statistics and probability domains. From the general objectives and contents to the subject achievement standards, discuss the similarities and differences based on the pure presentation and statement of the national curriculum in Korea and China (the translation of the necessary contents

for this research is displayed in the Appendix).

(2) Utilize study tools such as summary table to display the core contents in each country's textbooks, and make flowchart to visually present the statistics knowledge structure embedded in the teaching contents. Combined with the comparison results from national curriculum, explore the statistics literacy achievements especially concerning the statistical investigation process in two countries' statistical education.

There are several notifications of the tables and flowcharts utilized in this paper. Firstly, the textbooks will be summarized and presented in table from two separate perspectives, didactical aim and learning content. Each book from 7^{th} grade to 8^{th} and 9^{th} grade will be shown in time sequence. Secondly, the knowledge structure embedded in each of the textbooks is demonstrated by one flowchart in the beginning, and a big flowchart consists of knowledge structure on all three years' textbooks in middle school will be shown respectively in Korea and China. To be noted, in the Chinese textbook employed in this research, the knowledge structures are given in the end of every unit while such structures are not found in the Korean textbook or other official materials so I made the flowcharts of Korean middle school statistics knowledge structure by my own understanding of the textbook. Thirdly, there are a variety of marks in the flowcharts to be noted. In general, a section of line means a tight connection between knowledge, while a line with an arrowhead shows the deepening process from one knowledge to the next; in some of the flowcharts, a dot frame means that the knowledge is not clearly

addressed or given any definition on the textbook, but it may appear on the book or be highly related to other knowledge so that probably will be taught in class; a blue colored frame means in the knowledge structure, this knowledge point does not have enough weightiness to be shown in the flowchart, however for the comparison aim, it may illustrate certain difference between two countries; there are some significant additional contents that the national curriculum ('15) specifically mandated, and both of the new textbooks of 7^{th} and 8^{th} grades have changed according to the new curriculum, so the author plan to add those contents to the know structure of the new textbook in 9^{th} grade based on the added requirements in national curriculum ('15), and those parts are in grey color; in the entire knowledge structure flowcharts, the blue and grey dot lines try to generate a knowledge circle that might be able to reveal the statistical investigation process inside the structure.

(3) Referring to the framework and examples illustrated by GAISE (Franklin, 2005), compare the similarities and differences between two curricula and mathematics textbooks in compliance with the theoretical framework in this paper.

In this comparative study, a checklist of Korean and Chinese statistics education contents will be served as the theoretical framework to reveal the statistical literacy in middle school level in two countries. Checking whether each of the components in this list is included in the middle school statistics education contents helps to explore and compare the similarity and differences in two countries. The checklist is shown below:

Table 2 Checklist of middle school statistics education contents in Korea and China based on GAISE report (Franklin, 2005)

Component	Middle School Level
I. Formulate Question	● Is formulating questions for statistical problems taught? ● Are the questions extended to a larger scale than the class?
II. Collect Data	● Are sample surveys introduced? Do the students begin to use random selection? ● Is the comparative experiment taught?
III. Analyze Data	● Are measures of spread within a group taught? ● Is comparing two groups in tables and charts taught? ● Is sampling error introduced? ● Is the measure of association taught?
IV. Interpret Results	● Is the relationship between sample and population explained? ● Is the difference between two groups with different conditions introduced? ● Are observational study and experiment introduced? ● Are the strength and direction of association taught? ● Is interpretation of models for association required? ● Is the distinction between association and cause and effect introduced?
Nature of Variability	● Is sampling variability taught?
Focus on Variability	● Are variability within a group and variability between groups taught? ● Is any knowledge related to covariance and correlation taught?

The formation and contents in this checklist are mainly based on the components of statistical investigation process from the second column in Table 1. The Framework provided in GAISE (Franklin, 2005) has three developmental Levels from A to C, which may parallel grade levels based on development in

statistical literacy, not age. A student who is in the middle-school age but lacks of experience with statistics will need to start from Level A learning before he or she can move to Level B. Level C is seen as the academic level of high school, while Level B appears to involve most contents and standards in middle school level, therefore this paper takes Level B of the framework as the main focus to generate the components of the checklist.

IV. Comparison of Korean and Chinese National Mathematics Curricula at Middle School Level

In this section, the focal point is the analysis and comparison on the national mathematics curricula from Korea and China, including the general objectives, key competencies, achievement standards in the curriculum, and the reformations of national curriculum are also introduced in this section.

Curriculum has the possible influences that help guide the development of textbooks and learning paths embedded in textbooks. In many countries textbooks are a commonly used teaching resource that embodies the mandated curriculum. Therefore, it is important to analyze the curriculum documents themselves as they are the primary source on which teachers and textbook writers draw in creating learning resources and planning learning experiences (Fuson and Li, 2014). Thus it is necessary to analyze and compare the curricula in Korea and China before the study of textbooks in the next chapter. I analyzed and compared the general achievement objectives and standards on the statistics and probability of the curriculums of two countries (the translation is in Appendix) for understanding and comparing the similarities and differences of the basic concepts and contents. The results are interpreted in six sub-sections according to the statistics investigative process components in the checklist shown in Table 2.

1. General Achievement Objectives in Mathematics Curriculum

In this section, first a brief introduction and certain notification of the national curriculum is given. There is one more sub-section called “key competencies”, which is also a focal point in two countries’ curricula. The reason to include the contents of “key competencies” in the discussion of the general objectives is because they are closely related to each other and can be seen as a unity to analyze, and this unity aims to obtain more educational significance in the analysis of national curriculum.

1.1 The General Achievement Objectives in Korean National Mathematics Curriculum at Middle School Level

The most recent national curriculum in Korea is released in 2015. As mentioned previously, in this paper it will be abbreviated to Korean national curriculum ('15), or Korean new national curriculum for emphasis on the changes in the latest reform of curriculum. The translation of general achievement objectives in Korean national curriculum ('15) can be looked up in Appendix 1.1.

The three objectives seem to be very comprehensive and general, and for the statistics part, there is one segment named as ‘Generalized knowledge’ (Mathematics Curriculum No. 2015-74 [Separate volume 8], Page 8), and it might be seen as the general objectives on middle school statistics. The content of probability in this segment is ‘The probability of quantifying the likelihood of an event is an important tool for understanding the uncertainty of the information society’, and the content of statistics in this segment is ‘Statistics with gathering,

organizing, and interpreting data provides the basic data for rational decision-making'. These descriptions of probability and statistics in middle school are also quite general and vague to be a practical guidance.

1.2 The General Achievement Objectives in Chinese National Mathematics Curriculum at Middle School Level

The current version of the Chinese Mathematics Curriculum Standards (CMCS, Ministry of Education 2011), and I was given a book of Chinese national curriculum standards ((Compulsory Education) Mathematics Curriculum Standards (2011 version)), which will be used as the main material in this study.

Chinese general achievement objectives in mathematics curriculum at middle school level are in Appendix 2.1. In Chinese mathematics curriculum, the objectives are elaborated from four aspects, 1) knowledge and skills, 2) mathematical thinking, 3) problem solving, 4) feeling and attitude. These four aspects are not independent or split, but closely connected and interacted to an organic unity. Thus all of the objectives ought to be considered throughout the process of curriculum design and didactical activities. The realization of the entire objectives is the symbol of students being well educated in mathematics, and it has the significant meaning for students' comprehensive, sustainable and harmonious development. These are quite in common with Korean curriculum, while comparatively speaking, Korean curriculum stresses even more on students' application ability and requires the cognition of the connection between

mathematics and the real world throughout the whole process of acquiring mathematical skills.

Besides of the general objectives in mathematics, there is one chapter called ‘achievement contents’ and in this chapter of the curriculum, the general contents in different domains are suggested (the translation is presented in Appendix 2.2). The contents embody an outline of the statistical education in middle school, and the specific description makes it able to play a relatively explicit and qualified role of guidance for textbook editing and in-service teacher’s practice and other educational activities.

1.3 Key Competencies of Mathematics in National Curriculum

The mathematics education in middle school has a significant place in the whole education system. It is more important than universities to a certain extent, for the scale of students is much larger. Our modern society has been putting forward very realistic requirements for mathematics curriculum: what kind of mathematical competencies are needed for citizens in the future, and then it can be decided what kind of mathematical knowledge we should provide to students in middle school. With extensive deliberations on this topic, mathematics educators from two countries raised up their own opinions and through the latest mathematics curricula released by the Ministry of Education in Korea and China, it is not difficult to appreciate the distinction of focal points.

Based on the Korean national curriculum ('15) and Chinese national

curriculum, the key competencies of mathematics in two countries are presented in one table (Table 3), and the common components are connected by red lines for comparison.

Table 3 Key competencies in national mathematics curriculum in Korea and China

Korea	China
Problem solving	Number sense
Reasoning	Mathematical symbols
Creation and connection	Conception of space
Communication	Visual geometry
Data processing	Data analysis
Attitude and practice	Arithmetic capacity
	Reasoning capacity
	Modeling concept
	*application and creativity

The key competencies in middle school mathematics curriculum in Korea put more emphasis on students' socialization instead of the basic mathematical skills, and more related to the application and connection with the real world than the key competencies raised by Chinese mathematics educators, even though the new mathematics curriculum standard in China has already focus more attention on application than before.

Compared to the Chinese curriculum, the general achievement objectives and key competencies required in the Korean national curriculum ('15) seems to be much more affective and practical, for those explicit words such as connection, application, communication, attitude and practice, sympathy, etc., are strongly and clearly pointing to students' emotion and socialization. In Korea, the debates on what to teach in secondary mathematics classes are getting more and more intense especially in recent years, with the era of big data, meta-analysis and other technical impact on the whole world, many Korean educators try to make a difference on the rather conservative education system. The national mathematics curriculum ('15) is heading to a modern direction, whereas the implement of the national curriculum might be heading to other directions, and the vague or unspecific part in curriculum objectives and standards might take some responsibilities for it.

2. Middle School Statistics Achievement Standards in the National Mathematics Curriculum

2.1 Middle School Statistics Achievement Standards in the Korean National Curriculum

The achievement standards seem more stress on students' algorithmic ability rather than the application ability, which is not consistent with the general objectives.

To illustrate the inconsistency between the achievement standards and general objectives, some of the representative words from achievement standard

and general objectives are listed in the table below:

Table 4 A listing of representative words in Korean curriculum ('15)

Achievement Standards	General Achievement Objectives
Calculation of relative frequency	Observation, analysis, organization, expression, concepts, theories, rules, relation, skills
Calculation of number of cases and probability	Inference, communication, creative thinking, information processing ability, society and natural phenomena, problem solving
Calculation of median, mode, mean, variance and standard deviation	Interest, confidence, value, desirable attitude, practice ability

In Table 4, the three rows in the first column are showing the requirement of calculation ability in each year of the statistics study from the achievement standards. As noted in the achievement standards each of the standards is labeled by a code from [9M05-01] to [9M05-08] (Appendix 1.3), and the calculation is mentioned in five of the eight standards, that is, over half of the achievement standards stress on student's algorithmic ability. While as shown in the second column of Table 3, by the statements of the three general objectives, different

competencies are proposed, and these competencies, instead of pure calculation, are especially crucial in the statistical literacy.

2.2 Middle School Statistics Achievement Standards in the Chinese National Curriculum

Compared to the Korean curriculum, achievement standards in Chinese curriculum include a certain amount of knowledge within inferential statistics and statistical investigative process. However, the achievement standards also lack of some elements in statistical investigation and the variability of data.

Similar with the illustration of Korean curriculum, Table 5 shows a list of representative words in the Chinese national curriculum. While with the existence of the more specific objectives, achievement contents, I replaced the important words from general objectives with the words chosen from achievement contents. The words listed in Table 5 reflect a relatively more complete statistical investigation process. The word “calculation” is also addressed in the achievement standards in the Chinese curriculum, while different from the statement in the Korean curriculum, calculating of the representative values is followed with the emphasis on the description of the central tendency and dispersion degree instead of pure algorithmic ability. Besides, the expression about calculation is only found in two standards among the nine standards of “Sampling action and data analysis”, and no stress on calculation shows in “Event probability”. Last, the second column also presents the words related to the statistics investigative process, which shows

the coherence in the curriculum. However, some important activities during the investigative process such as posting questions before collecting data or describing the association between variables for interpreting data are missing.

Table 5 A listing of representative words in Chinese curriculum 2011

Achievement Standards	Achievement Contents
Collecting, organizing, describing, analyzing, data processing, calculator	Classification, criteria
Sampling, random sampling	Data collection, organization, investigation, measurement, presentation
Diagram, visualized	Analysis, expression, communication, information
Central tendency, dispersion degree	
Information, sample and population, estimation	
Prediction, communicating, variation tendency, random phenomena	
List, tree diagram, trial, estimated	

In the Korean national curricula, the missing of a clear range or substance of curriculum content makes the general objectives too general to comprehend what exactly to teach or implement in the following stages. The achievement standards

are not explicit or specific enough to directly serve as the guidance for teachers or textbook editors. Besides, there seems to be a lack of consistency with the general achievement objectives in Korean curriculum, as the achievement objectives and key competencies are both emphasizing on socialization, application and connection with real world instead of basic math skills. Through analyzing the Korean mathematics curriculum ('15) including its direction of revision, it comes to the conclusion that the connection with core competencies is crucial, in the meantime the characteristics of the subject of statistics needs to be considered to a great extent. The using of engineering tools is also one of revised directions, and it is hopeful that the utilization of engineering tools will help to reduce the strong emphasis on students' calculation skills.

The reform of Chinese curriculum is facing a rather complicated situation. Even though the newest curriculum for middle school has made a big progress in theory, the statistical investigation process need to draw more attention to be completely reflected by the national curriculum and corresponding teaching and learning materials.

3. Analysis and Comparison Using GAISE Framework

The framework suggested by GAISE (Franklin, 2005) contains components from investigative process to variability, which could be confusing if they are not labeled clearly. Thus the following explication will be divided into six parts according to the different components from the framework.

3.1 Formulate Question -- Increased awareness of the statistics question distinction

I examined the achievement standards in middle school curricula in both countries to check if the formulation of questions is included in the middle school curriculum. As a matter of fact, there is no requirement for students to formulate questions in Korean or Chinese national curriculum, and if the formulation of questions exists in statistical education, it might be included in the classroom activity guided by the teacher, therefore in the next chapter the search for the evidence of learning about formulation of question will be continued.

3.2 Collect Data -- Beginning awareness of design for differences

First, I examined the achievement standards and other related contents in middle school curricula in both countries. When some of the essential knowledge are not involved in the middle school curriculum, I tried to locate it in the curriculum of high school.

The sampling or other data collecting methods are not taught in middle school in Korea. However, according to the new national curriculum (Appendix 1.5), the knowledge about sampling is included in the third year of high school's statistics contents. About the experiment, there is no evidence in the national curriculum which shows that the knowledge of conducting comparative experiment or random allocation which is used for conducting comparative experiments exists in the secondary school statistics education in Korea. If the data collection is conducted

by teachers, it is probably during the activity of observational study, as the "Teaching • Learning Methods" (Mathematics Curriculum. Ministry of Education. Notification No. 2015-74 [Separate volume 8]. Page 39. (6)) implicates, "explore and collect appropriate data in real life and mathematical problems".

The Chinese national curriculum requires students to "comprehend the necessity of sampling, and get to know simple random sampling through examples" (Appendix 2.3). Similar with the situation in Korea, the national curriculum in China also seems to exclude designing and conducting any comparative experiments. The random allocation used for conducting comparative experiments is not found in the Chinese curriculum.

3.3 Analyze Data -- Learn to use particular properties of distributions as tools of analysis

With respect to data analysis, I examined the achievement standards in middle school curricula in both countries to check if the quantification of variability within a group (a population) is included in the middle school curriculum.

According to the Korean standards, for learning about the qualification variability within a group and comparison of group to group in displays, middle school students are required to master the calculation of representative values which can measure and reveal the scale of variability within a group in 9^{th} grade (Appendix 1.3 [9M05-06, 9M05-07]), and draw different kinds of plots and make tables in 7^{th} grade (Appendix 1.3 [9M05-01, 9M05-02, 9M05-03]). While the

formal statistics learning regarding sampling is beyond middle school level, the related knowledge of sampling will be taught in the third year of high school in Korea (Appendix 1.5). Besides, one of the most obvious changes of the new Korean national curriculum in middle school statistics part is the addition of knowledge related to association. Some simple quantification of association is involved in the third year of middle school statistics learning with the learning of scatter plot (Appendix 1.3).

In Chinese standards, the training of drawing graphs and making tables in 7th grade, and calculating representative values in 8th grade is highlighted in the national curriculum (Appendix 2.3 (I) 3. 4. 5. 6.). The Chinese standards require students skilled at quantifying variability within a group and comparing group to group in displays. However, unlike the Korean national curriculum's exclusion of sampling in middle school, the knowledge about sampling is introduced in the beginning of Chinese middle school statistics. The sample survey serves as one of the most important methods of data collection stressed by the Chinese national curriculum (Appendix 2.3 (I) 2.). Last, the association between variables and properties related to association are not involved in Chinese curriculum.

3.4 Interpret Results -- Students acknowledge that looking beyond the data is feasible

The formal statistics study about sampling will not be taught until the third year of high school in Korea. Korean middle school students should be able to describe

differences between two or more groups concerning center, spread, and shape. The achievement standards in national curriculum ('15) require 9th grade students to understand the meaning of median, mode, mean, variance and standard deviation, and also master the calculation of these representative values (Appendix 1.3 [9M05-06], [9M05-07]).

The strength and direction of association are introduced in 9th grade statistics learning. The Korean new national curriculum addressed that 'Correlation is divided into positive correlation, negative correlation, and no correlation' (Mathematics Curriculum. Ministry of Education. Notification No. 2015-74 [Separate volume 8]. Page 36. (2) Teaching • Learning Methods and Notes). The basic interpretation of association is mainly based on the scatter plots, as addressed in the curriculum: "Data can be expressed in terms of scatter diagrams and can be used to tell the correlation" (Appendix 1.3 [9M05-08]). With the scatter plot, similar with what GAISE (Franklin, 2005) explained: "if students have not yet been introduced to the equation of a line, then they simply might draw a line through the 'center of the data', in which way to find whether the correlation is negative, positive or none and achieve the 'basic interpretation of models for association'".

In the "Analyze Data" part, the statistics knowledge mandated by Chinese national curriculum is quite distinct from the one in Korean curriculum. Firstly, sampling and the relevant study are included in the Chinese curriculum, yet the requirement and description about it are not very specific. The experiment is

mentioned in the probability domain (Appendix 2.3 (II) 2.), but it is still not concrete enough to judge if the students need to "distinction between observational study and experiment". It is remained to be explored in the textbook and other materials. Lastly, the definition of association is not given to middle school students according to the Chinese curriculum, which is another difference from Korean new curriculum.

3.5 Nature of Variability

As discussed above, the learning on sampling is found in the Chinese curriculum. Since further contents such as estimating the population using sample will be taught in the 9^{th} grade, there is a great chance that the sampling variability exits at the middle school level in China. The concrete evidence need to be explored in the following chapters. In the Korean curriculum sampling does not exist in Korean middle school, so the variability in sampling is not introduced to students.

3.6 Focus on Variability

Students begin to compare measurements of different groups at middle school level, and in the statistics education of both countries, the variability between groups is introduced and trained through exercises, as well as variability within a group when they first acquire the measurements of central tendency and dispersion.

As regards "covariablity", GAISE (Franklin, 2005) explained: "the nature of this statistical relationship is described in terms of how the two variables 'co-

vary'". By this illustration, "covariablity" is not included in the Chinese national curriculum at middle school level, while it is related to the knowledge of correlation in the new national curriculum in Korea (Appendix 1.3).

V. Comparison of Korean and Chinese Middle School Textbooks

Korea and China share some similarities in terms of educational system and structure of curriculum. In both countries, there are three units in the middle school's mathematics textbooks related to statistics and probability, which are arranged throughout the 3 years' learning in middle school with each unit allocated in one semester of each academic year. Whereas some differences in contents and sequence of curriculum between two countries are apparent, it is not merely the result of differences in national curriculum, but some inconsistencies of the national curriculum and implementation generated through the process of editing the textbook. As defined previously, since this paper is an intra-educational analysis instead of intra-cultural analysis, those social cultural or political factors responsible for the inconsistency will not be discussed.

In this chapter, firstly textbook will be summarized and presented in table from two separate perspectives: didactical aim and learning content. Each book from 7^{th} grade to 9^{th} grade will be analyzed for learning sequence and instructions included in front pages respectively for each country followed by a short discussion on the comparison of the textbooks from two countries. Secondly flowcharts are utilized to visually illustrate the statistics knowledge structure presented in each textbook. Each textbook is demonstrated by one flowchart in the beginning, and one flowchart for the entire knowledge structure in middle school will be shown respectively for Korea and China, followed by a relatively

comprehensive comparison analysis.

Finally, the statistical contents and knowledge structure in textbooks of Korea and China will be further compared with the GAISE (Franklin, 2005) framework. Since there are six different components regarding investigative process and variability: “formulate question”, “collect data”, “analyze data”, “interpret results”, “nature of variability” and “focus on variability”, it is more explicit to examine the related parts one by one and compare each of the components. Thus the analysis will be divided into six subsections according to the components of the framework.

1. Learning Contents in Statistics Included in the Textbooks of Korea and China

Characteristics of textbooks will be summarized and presented in a table from two separate perspectives, didactical aim and learning content. Each book from 7^{th} grade to 8^{th} and 9^{th} grade will be shown in time sequence, with all the details and special notifications of textbooks introduced in the front respectively in each country, and followed by a short discussion on the comparison based on the summary of the textbooks in two countries.

1.1 Middle School Statistics Textbook Content in Korea

In Korea, the education system is known as highly centralized and unified across the country. However, different textbooks from independent publishers are used across the country. This paper employed the textbook from Donga Press (Woo

Jungho, 2009 revision; Park Kyosik, 2015 revision). The textbook ('09) has been implemented for years, while the new textbook ('15) for 9th grade has not been published yet. Therefore, I will analyze the textbook ('09) for 9th grade of Korea instead. Since new curriculum is announced, I will also fill the gap with the achievement standards presented in the new curriculum document.

The summary tables are divided into two categories, one is for presenting the didactical aims from the textbooks and the other is for illustrating the learning contents on textbooks. Different school years' textbooks a summarized as follows:

Table 6 Statistics didactical aim in 7th grade Korean textbook ('09)

Section	Frequency Distribution and Graph
After learning this section:	1) Analyze stem-and-leaf plot, frequency distribution table, histogram and frequency polygon 2) Calculate mean given the frequency distribution table 3) Get relative frequency and present it in graphs, and understand the distribution of relative frequency
The basis of statistics is data collection and organization	In this section, learn using table or graph based on different aims to present the collected data.

Table 7 Statistics didactical aim in 7th grade Korean textbook ('15)

Section	Data organization and analysis
After learning this unit:	Use steam-and-leaf plot, frequency distribution table, histogram and frequency polygon to organize and analyze different kinds of data.

Table 8 Statistics contents in 7th grade Korean textbook ('09)

Sub-section	Content
Stem-and-leaf plot	Definition of variable, draw the plot
Frequency distribution table	Make the table, calculate mean
Histogram and frequency polygon	Draw graphs, comparison of two graphs
Relative frequency	Calculation, comparison with frequency
Problem solving	Swimming team
Computer	Use statistics program to draw histogram

Table 9 Statistics contents in 7th grade Korean textbook ('15)

Sub-section	Content
Stem-and-leaf plot	Definition of variable, draw the plot
Frequency distribution table	Make the table, use computer to make table
Histogram and	Draw graphs, use computer to draw graphs

frequency polygon	
04 Relative frequency	Calculation, draw relative frequency polygon, use computer to calculate relative frequency and draw relative frequency polygon
Exercise and activity	Make statistics poster: decide a subject, make a plan, collect the data, analyze the data, organize results

Table 10 Statistics didactical aim in 8th grade Korean textbook ('09)

Section	Number of cases and probability, Calculation of probability
After learning this section:	1) Know how to get the number of cases. 2) Understand the meaning and basic properties of probability. 3) Calculate probability.
In this section	Learn about how to calculate number of cases, meaning and basic properties of probability, and calculate probability.

Table 11 Statistics didactical aim in 8th grade Korean textbook ('15)

Section	Probability and its basic properties
After learning this unit	1) Understand the number of cases. 2) Acquire the calculation of probability.

Table 12 Statistics contents in 8th grade Korean textbook ('09)

Sub-section	Content
Number of cases	1) Definition of event 2) Calculation
Meaning of probability	Frequency table and formula
Problem solving	Glass craft experiential learning
Basic properties of probability	P (complementary of A) = 1-P (A).
Calculation of probability	Calculation of mutually exclusive event and independent event
Problem solving	Regular pentagon and probability
Statistics program	The experiment of toss of coin on some website

Table 13 Statistics contents in 8th grade Korean textbook ('15)

Sub-section	Content
Number of cases	1) Definition of event 2) Calculation of mutually exclusive event and independent event
Probability	1) Frequency table, possibility p=a/n 2) Properties: P (complementary of A) = 1-P (A) 3) Calculation of mutually exclusive event and

	independent event
Exercise	Talking and thinking
Computer	The experiment of toss of dice via computer program

Table 14 Statistics didactical aim in 9th grade Korean textbook ('09)

Section	Representative value and measure of dispersion
After learning this section:	1) Understand and calculate the median, mode and average. 2) Understand and calculate variance and standard deviation.
In this section	Learn about representative value and measure of dispersion of data.

Table 15 Statistics contents in 9th grade Korean textbook ('09)

Sub-section	Content
Representative value	Median, mode and mean
Measure of dispersion	Deviation, variance, standard deviation
Problem solving	The change of mode of a data set
Statistics program	Use excel to calculate statistical values

1.2 Middle School Statistics Textbook Content in China

The textbook published by PEP will be analyzed and compared with the Korean textbook. PEP textbook is well aligned with the national curriculum. The content of the PEP version is relatively difficult, but the logical relationship between

different knowledge components is explicitly stated compared to other textbooks.

For the PEP textbooks, the summary tables are divided into two categories, one is for presenting the didactical aims from the textbooks and the other is for illustrating the learning contents. Different school years' textbooks a summarized as follows:

Table 16 Statistics Didactical Aim in 7th Grade Chinese Textbook

Section	Statistics
Knowledge and skill	Translate the real life problems into mathematical problems, and solve the real problem through mathematical problems.
Feeling and attitude	Build the foundation for a worldview of dialectical materialism.

Table 17 Statistics Contents in 7th Grade Chinese Textbook

Sub-section	Contents
Statistical investigation	Sector diagram, sampling survey, simple random sampling
Histogram	Draw histogram
Experiment and inquiry study	How many beans in the bottle
Project learning	Talking about the water conservation with data

Table 18 Statistics Didactical Aim in 8th Grade Chinese Textbook

Section	Statistics
Knowledge and skill	Master the method of analyzing the population with samples.
Feeling and attitude	Feel the connection between mathematics and daily life.

Table 19 Statistics Contents in 8th Grade Chinese Textbook

Sub-section	Contents
Central tendency of data	1)Average and weighted average 2)Median and mode
Degree of dispersion of data	Variance
Reading and thinking	comparison of average, extreme difference, mean difference, variance and standard deviation
Project learning	Data analysis in a health test

Table 20 Statistics Didactical Aim in 9th Grade Chinese Textbook

Section	Probability
Knowledge and skill	Understanding the application of probability in life.
Feeling and attitude	Further feel the connection between mathematics and daily life, meanwhile educate students on the dialectical materialism world outlook.

Table 21 Statistics Contents in 9th Grade Chinese Textbook

Sub-section	Contents
Random event and probability	1) Random event 2) Probability
Calculate probability by listing technique	Tree diagram
Estimate probability with frequency	Estimation of population mean and variance
Reading and thinking	Probability and lottery
Experiment and inquiry study	Estimation of π

1.3 Comparison of Middle School Statistics Textbook Content in Korean and China

First, the common contents are obvious, which are in the knowledge related to data organization and description, including frequency table and histogram, and the requirement of some basic data analysis in class activities.

There are also some differences. Regarding the didactical aim in the front of every section, the Korean textbooks focus on the learning of knowledge in the contents while the Chinese textbooks include the requirement of application ability and the connection with real life. With respect to the content of the textbooks, there are several distinctions. Although the emphasis of calculation is one of the main

features in both countries, in Korea the proportion of numerical algorithm is even larger and the calculation is more complicated, such as the calculation of standard deviation, the number of cases and probability of mutually exclusive events and independent events. However, the essential and fundamental knowledge in the process of statistical investigation such as sampling, estimating the population, etc. are only mentioned in an activity in the end of this unit in the Korean textbooks. The Chinese textbooks appear to cover the most essential methods and tools for the primary data processing, for the knowledge of data collection (e.g. sampling), organization (e.g. frequency table), analysis (e.g. representative value) and interpretation (e.g. estimation of the population) can all be found in the contents.

2. Knowledge Structure and Learning Sequence of Statistics Contents in Textbooks of Korea and China

In this section, I will illustrate the knowledge structure of learning contents of statistics in textbooks of Korea and China. Each textbook is demonstrated by one flowchart in the beginning, and a flowchart for knowledge structure on all three textbooks in middle school will be shown respectively in Korea and China, followed by a relatively comprehensive comparison analysis in the end.

2.1 Knowledge Structure and Learning Sequence of Statistics Contents in Different School Years' Textbooks of Korea and China

Before the illustration of statistics knowledge structure on textbooks of different

school years, there are some facts to be noted. Firstly, in both countries, the contents of statistics and probability on textbook are divided into three parts, the domain of statistics takes two parts and probability takes one, and each of them is arranged in the different school years for students to learn. While one of the most apparent distinctions in two countries, except the obvious differences on the specific contents, is the order of learning probability knowledge, which might be ignored or taken lightly regardless of the whole structure of statistics knowledge in middle school, so it will be stressed again in the next analysis and comparison section.

(1) Representing the data by graphs and tables

Both countries' textbooks start the domain of statistics in the second semester of 7th grade. The Figure 1 and Figure 2 are flowcharts of statistics knowledge structure on textbook of 7th grade in Korea and China respectively.

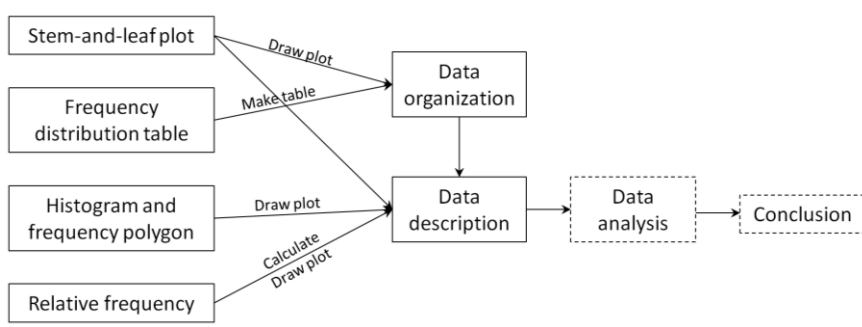


Figure 1 Flowchart of statistics knowledge structure in 7th grade Korean textbook ('15)

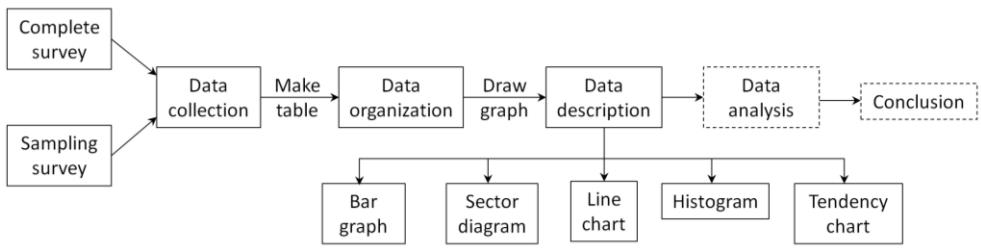


Figure 2 Flowchart of statistics knowledge structure in 7th grade Chinese textbook

To be noted, the dotted rectangle means that the knowledge is not clearly addressed or given any definition on the textbook, while it seems highly related to other knowledge so that probably will be taught in class.

From the two flowcharts of the knowledge structure of the texts of two countries above, some similarities and differences could be revealed. First, there are many similar contents, which are also shown in the former section. However, the flow and path in Figure 1 and Figure 2 are rather different. In Korea, the learning starts with certain graphs and tables, and then some parts of the statistical investigation process are taught. Due to this start, the data collection such as sampling is not included in this process. Generally the whole structure just focuses on the data representation tools. While in Figure 2, a rather explicit path of investigation process flows from left to right, and the methods and tools for representing data are shown as branches on the path.

(2) Measures of center and dispersion

The arrangements of measures of center and dispersion in middle textbooks

are different. In Korean textbook, the measures of center and dispersion are taught in 8th grade whereas in the Chinese textbook this part is taught in 9th grade.

Since the newest version of Korean textbook will not be released until this summer, whereas this paper will be written by then, so for the study of 9th grade textbook, the author has no choice but use the textbook ('09) to continue. Some inconsistency may occur during the analysis, which will be discussed later.

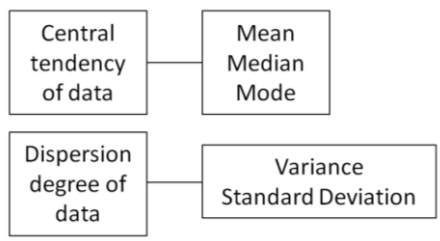


Figure 3 Flowchart of statistics knowledge structure in Korean 9th grade textbook ('09)

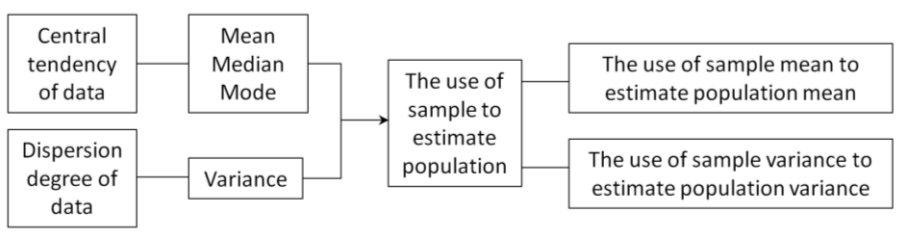


Figure 4 Flowchart of statistics knowledge structure in 8th grade Chinese textbook

The similarity revealed from Figure 3 and Figure 4 is that the basic description of data sets, central tendency and dispersion degree are both emphasized in two countries with four common representative values, which are mean, median, mode and variance. And the difference is, the Korea textbook

includes one more representative value, standard deviation and it is not taught to Chinese middle school students. In China, standard deviation is not introduced here, but more contents related to inferential statistics knowledge are involved, such as the use of sample to estimate population. While in Korea the use of sample to estimate populations is taught in the high school as a selective curriculum (usually in 11th or 12th grade).

(3) Probability

As mentioned above, the school year of learning this chapter is different in Korea and China. Here is the comparison of Korean 8th grade textbook and Chinese 9th grade textbook.

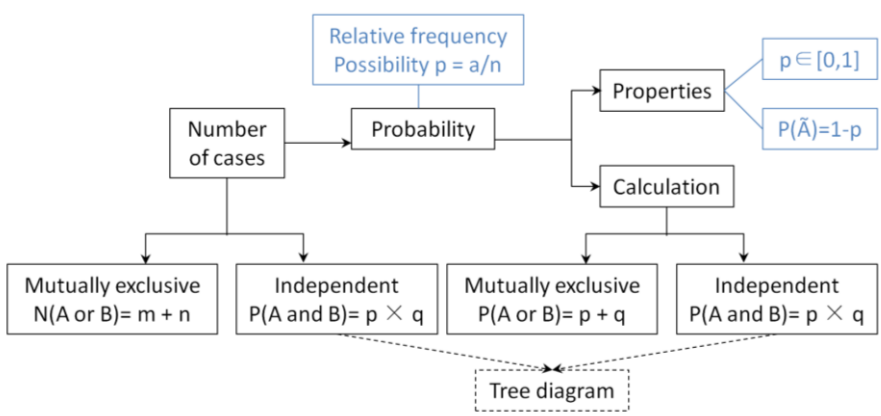


Figure 5 Flowchart of statistics knowledge structure in Korean 8th grade textbook ('15)

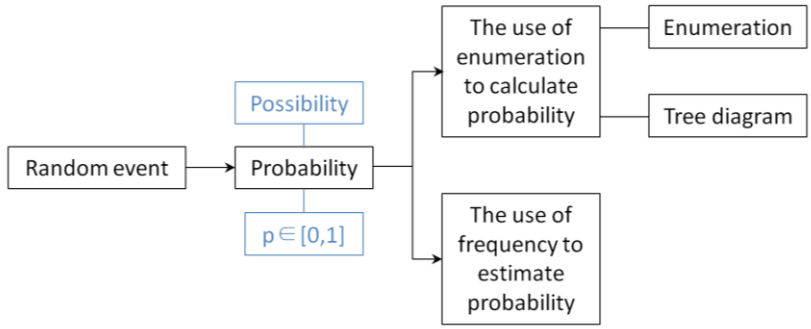


Figure 6 Flowchart of statistics knowledge structure in 9th grade Chinese textbook

Noted that the blue colored frame means in the knowledge structure, this knowledge point does not have enough weightiness to be shown in the structure, however for the comparison aim, I include it to illustrate the differences in statistics education between two countries. From the blue colored frame, it is clear to observe the proportion and difficulty of calculation contents in each structure. In Korea, the calculation contents in probability take a heavier place than China.

Here the similarity is that in both countries, it starts with events or cases to introduce the concept of probability. The main difference lays on the time to learning probability in middle is different in two countries. In Korean textbook, the unit of probability is put in the end of 8^{th} grade, while in China it is in the first semester of 9^{th} grade after all the data handling strand in middle school. The structure of knowledge in all three years' learning in middle will be discussed later. Besides, Korean textbook still put more emphasis on calculation in most parts of the structure. Relatively complicated situations and relations of events are included when teaching the number of cases and probability. On the other side, Chinese

textbook contains simpler calculation combined with inferential statistics knowledge. The concept of estimation is included, and this is also a foundation for learning prediction in statistics, which could be seen as a clear sign to show the reason why putting probability as a part of statistics learning instead of pure mathematics in this unit. The connection between probability and inferential reasoning is reflected significantly.

(4) Comparison of Textbooks Based on Contents and Knowledge Structure

With the specified comparison in each sub-domain between two countries, the flowchart of the entire statistics knowledge structure in the middle school textbook consist with knowledge structure on all three textbooks in middle school will be shown respectively in Korea and China. Through the whole structure illustrated in each country, a relatively comprehensive conclusion will be reached in the end.

Since the new textbook of 9^{th} grade has not been released yet, for the coherency of knowledge structure in three years' learning, here the big flowchart of the whole content in middle school in Korea is merely based on the former version of textbook published in 2009. While the changes and some improvement on the structure the new textbook seem to have achieved will be taken consideration in the following and discussed in details during the comparison with the knowledge structure on Chinese textbook.

The flowchart in Figure 7 shows the statistical knowledge structure in Korean

middle school with concrete evidence, which is the published textbook ('09). To be noted, the dot lines in blue color are trying to connect the elements in the process of statistical investigation.

There are some more contents that the national curriculum ('15) specifically mandated, and both of the new textbooks of 7th and 8th grades have changed according to the new curriculum. Thus the path in the flowchart in Figure 8 has been estimated based on the curriculum ('15) and the curriculum before ('09) where the scatter plot and the correlation have been included. The flow chart has been confirmed by a current writer of the new 9th grade textbook, which will be published soon.

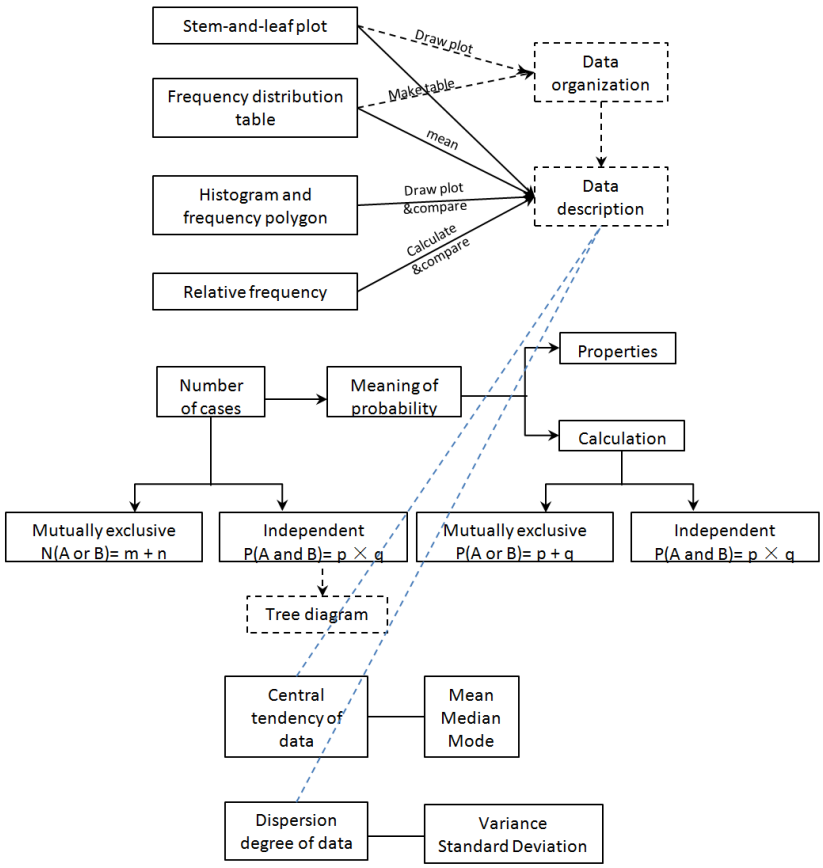


Figure 7 Flowchart of statistics knowledge structure in Korean middle school textbook ('09)

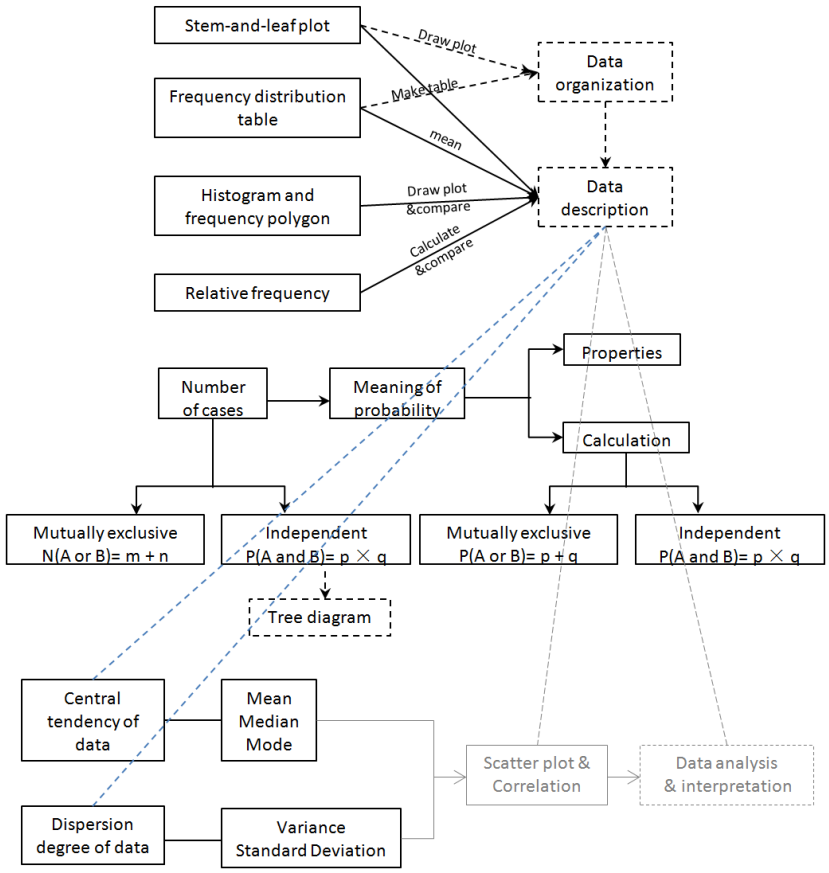


Figure 8 Flowchart of statistics knowledge structure in Korean middle school Korea textbook ('15)

Similar with the flowchart in Figure 7 and 8, there are also dot lines in blue color that connect the related elements in statistical investigation process in the flowchart showed in Figure 9. Besides, for clarity some of the key words which indicate the investigative components in the frames are circled.

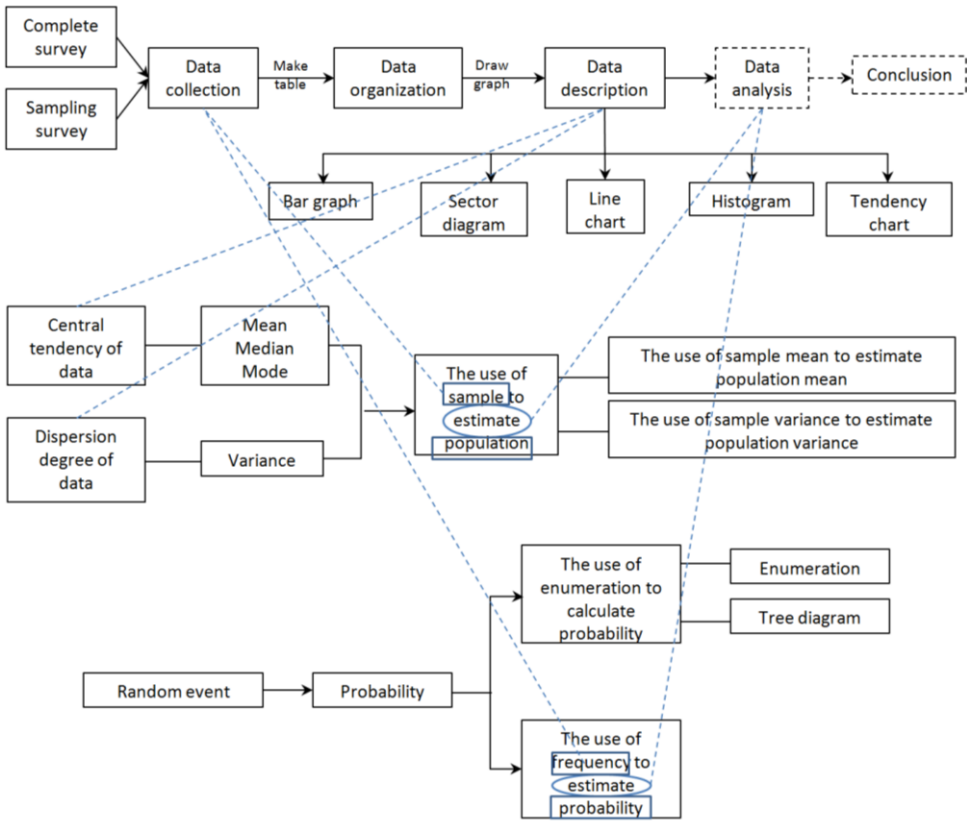


Figure 9 Flowchart of statistics knowledge structure in Chinese middle school textbook

Through these flowcharts above, it is not difficult to find the different features of the statistics knowledge structures in two countries' textbooks in middle school. Generally, the knowledge structures of Chinese textbook embodies a more complete statistical investigation process, from data collection, data analysis to data interpretation with inferential statistics knowledge, which generate the blue dotted paths in the structure in Figure 9. In Figure 8, the grey part indicates the obvious change of the new textbook and by adding the contents of "scatter plot and correlation", the more analysis tools to conduct statistical investigation are

given in the middle school. However, the "collecting data" is not included in the Korean curriculum. Furthermore, the learning of probability in the second year of middle school not only exposes the problem of too much calculative requirement, but also shows the neglect of the relation between probability and statistics.

3. Analysis of Textbooks of Korea and China Based on GAISE Framework

The analysis and comparison will be further conducted based on the framework and suggestions by GAISE report (Franklin, 2005).

As explained in the beginning of this chapter, since there are six different components in the investigative process and variability of data, which are “formulate question”, “collect data”, “analyze data”, “interpret results”, “nature of variability” and “focus on variability”, it is more explicit to examine the related parts one by one and compare each of the components. Thus the analysis below will be divided into six subsections according to the components of the framework.

3.1 Formulate Question -- Increased awareness of the statistics question distinction

With respect to “Formulate Question”, there is no task in Korean textbook that students are expected to do any exercises or activities regarding formulation of question. While in China, according to the textbook published by PEP, the middle school statistics begins with a chapter named “Statistics Investigation”, from where students start to put forward questions not restricted to the classroom and the population of the questions could be extended to the whole school or a larger

scale. At first they are told how to formulate an appropriate question, especially after learning the sampling survey the students are required to formulate survey questions. To get prepared for the formulating their own questions, there are some exercises which lead them to choose the appropriate questions, for instance, in the exercise 2 on page 141 of PEP's 7th grade mathematics textbook (Figure 10), students need to choose between two given question: "(1) Don't you think the science fiction film is much more interesting than the documentary film?" and "(2) Which type of film do you like better – science fiction film or documentary film?" and decide which question is better to address for designing and conducting a sampling survey. While in this example, it is not sure whether the question is restricted to the classroom or not, but it does not affect the purpose of this exercise. Besides, there are some other factors to consider for designing the questionnaire and conducting the sample survey, which will be stressed in the "Collect Data" component, and this holds the same view with GAISE at Level B that "It is important for students to realize that the conclusions from their study depend on the accuracy of their data" (Franklin, 2005).

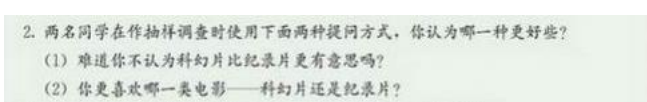
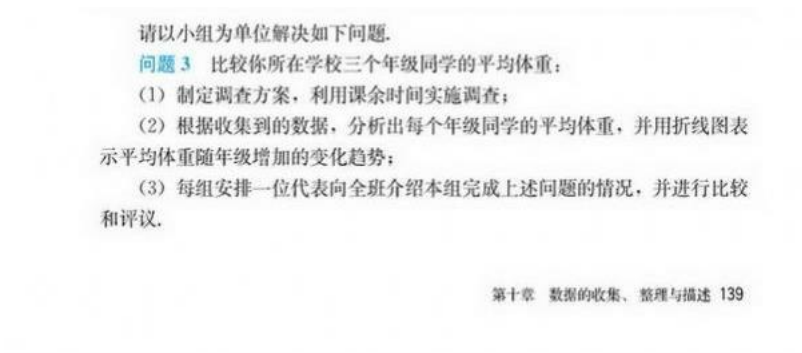

2. 两名同学在作抽样调查时使用下面两种提问方式，你认为哪一种更好些？
(1) 难道你不认为科幻片比纪录片更有意思吗？
(2) 你更喜欢哪一类电影——科幻片还是纪录片？

Figure 10 Exercise 2 on page 141 of PEP 7th grade mathematics textbook

Furthermore, some questions are extended to a population of different grades in school, such as the one showed in Figure 11, which is a group activity with the

problem of “compare the average weight of students among different grades in your school”.



请以小组为单位解决如下问题.

问题 3　比较你所在学校三个年级同学的平均体重：

(1) 制定调查方案，利用课余时间实施调查；

(2) 根据收集到的数据，分析出每个年级同学的平均体重，并用折线图表示平均体重随年级增加的变化趋势；

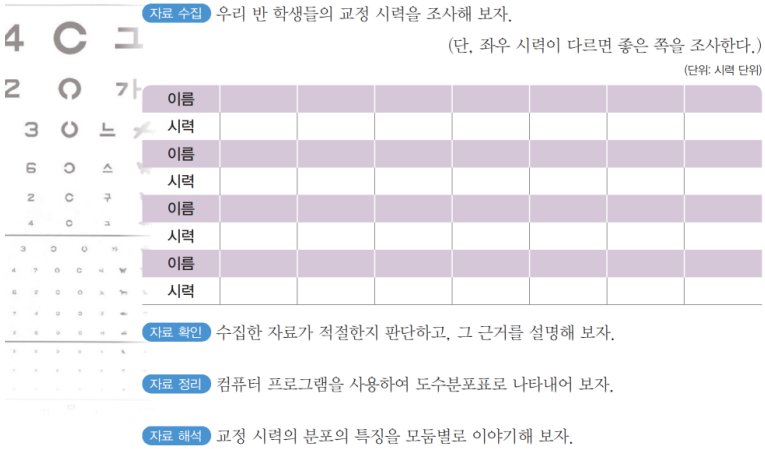
(3) 每组安排一位代表向全班介绍本组完成上述问题的情况，并进行比较和评议.

第十章　数据的收集、整理与描述 139

Figure 11 Problem 3 on page 139 of PEP 7th grade mathematics textbook

3.2 Collect Data -- Beginning awareness of design for differences

The second component in the framework, “Collect Data”, consists of the knowledge related to sampling and experiment, which is excluded in Korean middle school textbook. However, some activities involving data collection are found in 7th grade textbook ('15). For instance, Figure 12 shows a task asking to collect the corrected visual acuity of students in the class, and then organize and describe the data. To be noted, this kind of activities are not belonging to the main parts in the textbook, but showing as "extra projects".



자료 수집 우리 반 학생들의 교정 시력을 조사해 보자.

(단, 좌우 시력이 다르면 좋은 쪽을 조사한다.)

(단위: 시력 단위)

이름							
시력							
이름							
시력							
이름							
시력							
이름							
시력							

자료 확인 수집한 자료가 적절한지 판단하고, 그 근거를 설명해 보자.

자료 정리 컴퓨터 프로그램을 사용하여 도수분포표로 나타내어 보자.

자료 해석 교정 시력의 분포의 특징을 모둠별로 이야기해 보자.

Figure 12 Exercise 3 on page 253 of Donga 7th grade mathematics textbook ('15)

在上面的调查中，我们利用调查问卷得到全班同学喜爱电视节目的数据，利用表格整理数据，并用统计图进行直观形象的描述．通过分析表和图，了解到了全班同学喜爱电视节目的情况．在这个调查中，全班同学是要考察的全体对象，我们对全体对象都进行了调查．像这样考察全体对象的调查叫做**全面调查**．例如，2010 年我国进行的第六次人口普查，就是一次全面调查．

练习

1. 小明为了解同学们的课余生活，设计了如下调查问题：
   你平时最喜欢的一项课余活动是（　　）．
   (A) 看课外书　　(B) 体育活动　　(C) 看电视　　(D) 踢足球
   你认为此问题的答案选项设计合理吗？为什么？如果不合理，请修改．
2. 经调查，某班学生上学所用的交通工具中，自行车占 60%，公交车占 30%，其他占 10%，请画出扇形图描述以上统计数据．
3. 请你举出一些生活中运用全面调查的例子．

问题 2　某校有 2 000 名学生，要想了解全校学生对新闻、体育、动画、娱乐、戏曲五类电视节目的喜爱情况，怎样进行调查？

可以用全面调查的方法对全校学生逐个进行调查，然后整理收集到的数据，统计出全校学生对五类电视节目的喜爱情况．但是，由于学生比较多，全面调查花费的时间长，消耗的人力、物力大．因此，需要寻找一种不作全面调查就能了解全校学生喜爱各类电视节目的情况的方法，达到既省时省力又能解决问题的目的．这就是我们要讨论的抽样调查．

抽样调查（sampling survey）是这样一种方法，它只抽取一部分对象进行调查，然后根据调查数据推断全体对象的情况．在问题 2 中，我们只抽取一部分学生进行调查，然后通过分析被调查学生的数据来推断全校学生喜爱电视节目的情况．全校学生是要考察的全体对象，称为总体，组成总体的每一个学生称为个体，而被抽取调查的那部分学生构成总体的一个样本．

为了强调调查目的，人们有时也把全校学生喜爱的电视节目作为总体，每一个学生喜爱的电视节目作为个体．

Figure 13 Definition of complete survey and sampling survey on PEP 7th grade mathematics textbook

In China, the complete survey and sampling survey are defined with the posting of corresponding questions and exercises in 7th grade, as figure 13 shows.

After the introduction of survey, students are expected to start using random selection as one of the sampling methods. The definition of simple random sampling is given on page 139 of PEP's 7th grade mathematics textbook: the simple random sampling is a method by which every member of a population has an equal chance of being selected (Figure 14). The GAISE (Franklin, 2005) proposed a further explanation, "In statistics, randomness and probability are incorporated into the sample selection procedure in order to provide a method that is 'fair' and to improve the chances of selecting a representative sample. This application illustrates one of the roles of probability in statistics."


从表 10-2 可以看出，样本中喜爱娱乐节目的学生最多，为 38%．据此可以估计出，这个学校的学生中，喜爱娱乐节目的最多，约为 38%左右．类似地，由上表可以估计这个学校喜爱其他节目的学生的百分比，如图 10.1-2 所示．

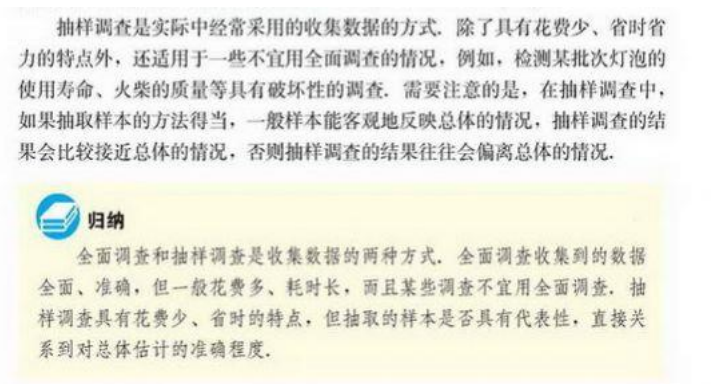
图 10.1-2

上面抽取样本的过程中，总体中的每一个个体都有相等的机会被抽到，像这样的抽样方法是一种简单随机抽样（simple random sampling）．

Figure 14 Definition of simple random sampling on PEP 7th grade mathematics textbook

The learning of simple random sampling is followed by the summary of different properties of complete survey and sampling survey as the Figure 15

shows. It is clarified that a sample may not be representative of the large population if the method of selecting the sample is inappropriate and furthermore, and it will affect the accuracy of estimating the population. This is once again an emphasis on students' recognition of the accuracy of data, which is crucial to the analysis and conclusion.


抽样调查是实际中经常采用的收集数据的方式. 除了具有花费少、省时省力的特点外，还适用于一些不宜用全面调查的情况，例如，检测某批次灯泡的使用寿命、火柴的质量等具有破坏性的调查. 需要注意的是，在抽样调查中，如果抽取样本的方法得当，一般样本能客观地反映总体的情况，抽样调查的结果会比较接近总体的情况，否则抽样调查的结果往往会偏离总体的情况.

归纳

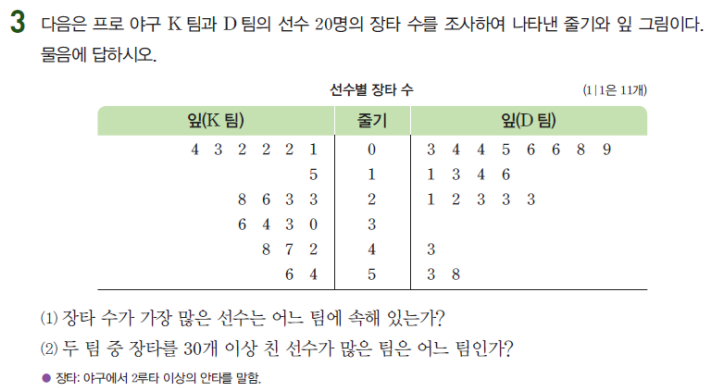
全面调查和抽样调查是收集数据的两种方式. 全面调查收集到的数据全面、准确，但一般花费多、耗时长，而且某些调查不宜用全面调查. 抽样调查具有花费少、省时的特点，但抽取的样本是否具有代表性，直接关系到对总体估计的准确程度.

Figure 15 Properties of complete survey and sampling survey on PEP 7th grade mathematics textbook

On the bottom of this page there is an exercise, that is "Problem 3" in Figure 11, mentioned in "Formulate Question", and just like the GAISE (Franklin, 2005) addressed in the description of Level B, "although Level B students may not actually employ a random selection procedure when collecting data, issues related to obtaining representative samples should be discussed at this level." Finally, similar with the situation in Korea, the secondary school statistics education in China also seems to exclude the contents of designing and conducting any comparative experiments.

3.3 Analyze Data -- Learn to use particular properties of distributions as tools of analysis

First, for learning the measure of variability within a group and comparison of group to group in displays, middle school students in Korea are required to master the calculation of representative values which can reveal the scale of variability within a group in 9th grade, and draw several different kinds of plots and make tables in 7th grade, which is described in the former chapters in details. In Figure 16, there is an exercise for comparing the number of players' extra-base hit in two teams using a steam-and-leaf plot, and it raised up two simple quantification questions: "(1) Which team does the player who has the most extra-base hits belong to? (2) Which team owns more players who have over 30 times extra-base hits?"



3 다음은 프로 야구 K 팀과 D 팀의 선수 20명의 장타 수를 조사하여 나타낸 줄기와 잎 그림이다. 물음에 답하시오.

선수별 장타 수 (1|1은 11개)

잎(K 팀)	줄기	잎(D 팀)
4 3 2 2 2 1	0	3 4 4 5 6 6 8 9
5	1	1 3 4 6
8 6 3 3	2	1 2 3 3 3
6 4 3 0	3	
8 7 2	4	3
6 4	5	3 8

(1) 장타 수가 가장 많은 선수는 어느 팀에 속해 있는가?

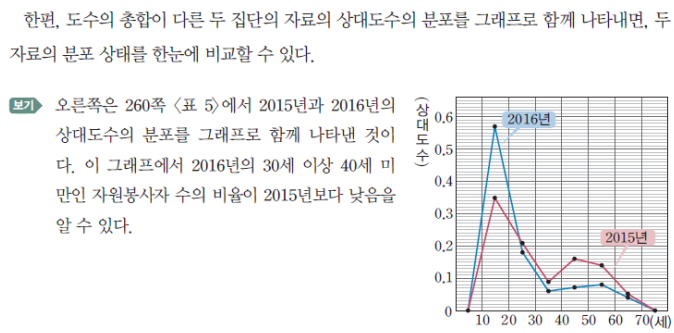
(2) 두 팀 중 장타를 30개 이상 친 선수가 많은 팀은 어느 팀인가?

● 장타: 야구에서 2루타 이상의 안타를 말함.

Figure 16 Exercise 3 on page 246 of Donga 7th grade mathematics textbook ('15)

"Comparing two groups" are not explicitly included as standards in Korean

curriculum, but some tasks in the textbooks require such ability. Figure 17 shows an example of comparing two relative frequency distributions of volunteer workers at different ages in the year of 2015 and the year of 2016, using frequency distribution polygons. The ability to solve this problem is built on the acquirement of the concept of relative frequency table, which is taught right before asking students of comparing two groups.


한편, 도수의 총합이 다른 두 집단의 자료의 상대도수의 분포를 그래프로 함께 나타내면, 두 자료의 분포 상태를 한눈에 비교할 수 있다.

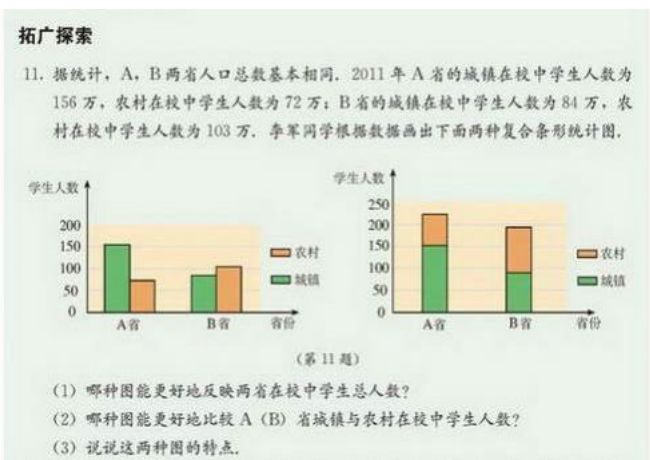
보기 오른쪽은 260쪽 〈표 5〉에서 2015년과 2016년의 상대도수의 분포를 그래프로 함께 나타낸 것이다. 이 그래프에서 2016년의 30세 이상 40세 미만인 자원봉사자 수의 비율이 2015년보다 낮음을 알 수 있다.

Figure 17 Example on page 262 of Donga 7th grade mathematics textbook ('15)

The requirement of acknowledging sampling error is not found in the Korean middle school textbook. While as stated in the last chapter, one of the most obvious changes of the new Korean national curriculum in middle school statistics part is the addition of knowledge related to association. It is explicit that simple quantification of association will be involved in the third year of middle school statistics by learning the scatter plot.

It has been discussed in the former chapters that the training of drawing graphs and making tables in 7th grade, and calculating representative values in 8th

grade in Chinese middle schools is also highly emphasized by the national curriculum and textbooks in China, which provides the students adequate practice for quantifying variability within a group and comparing group to group in displays. In Figure 18, one exercise in the textbook of 7th grade is presented to illustrate the deepening study of comparing group to group in displays. Exercise 11 (Figure 18) gives two different ways of drawing the histogram regarding to the same data. The histograms display the number of students in city and countryside of province A and province B, and the questions are leading students to discuss the features of two different presentations of histogram.


拓广探索

11. 据统计，A，B两省人口总数基本相同．2011年A省的城镇在校中学生人数为156万，农村在校中学生人数为72万；B省的城镇在校中学生人数为84万，农村在校中学生人数为103万．李军同学根据数据画出下面两种复合条形统计图．

（第11题）

（1）哪种图能更好地反映两省在校中学生总人数？

（2）哪种图能更好地比较A（B）省城镇与农村在校中学生人数？

（3）说说这两种图的特点．

Figure 18 Exercise 11 on page 143 of PEP 7th grade mathematics textbook

Unlike the Korean textbook's exclusion of sampling in middle school, the knowledge related to sampling is introduced in the beginning of Chinese middle school statistics study, with sample survey serving as one of the most important methods of data collection. After learning of collecting data, some properties of

sampling such as the sampling error is presented in textbook (Figure 15) to make sure they understand this data collection process as well as the consequences after it. Thus the students are expected to analyze the data with the consideration of variability caused by sampling.

In this "Analyze Data" segment, any knowledge about the association between variables is not involved in Chinese middle school textbook. In China students learn to analyze the association between two variables in high school. Thus middle students are not able to analyze two variables association, nonetheless to say the models for association.

3.4 Interpret Results -- Students acknowledge that looking beyond the data is feasible

Since the formal statistics study about sampling will not begin until the third year of high school in Korea, the knowledge regarding the property of sampling is certainly not included in middle school statistics contents.

With respect to the "difference between two groups with different conditions", Korean middle school students are asked to describe differences between two or more groups concerning center, spread, and shape in the textbook. For instance, in the textbook ('09) of 9^{th} grade, related exercises are give to enhance students' ability of comparing group to group with respect to the central tendency, dispersion and other features of the data distribution. Figure 19 presents a discussion prepared for students in the 9^{th} grade: talking about the characteristics

of students' math scores in Class A and Class B, and the given hints are regarding mean and standard deviation. This exercise can be seen an elaboration of exercise for comparing two groups in displays in Figure 17.

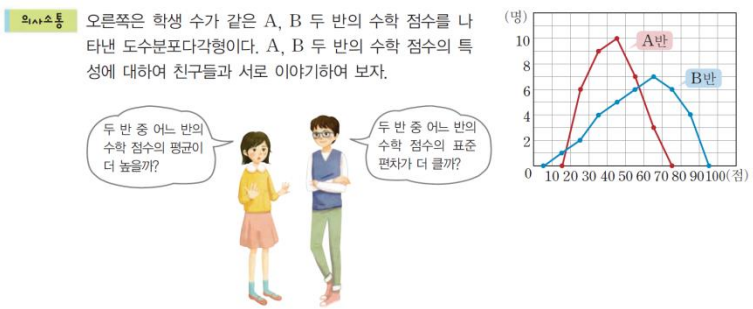


Figure 19 Discussion on page 168 of Donga 9th grade mathematics textbook ('09)

To be noted, the Korean curriculum or textbook does not clearly mandate the teaching of comparing two groups and how to interpret the results. However Korean textbooks include tasks such as the one in Figure 19 for students in the 9th grade, and ask students to compare representative values in two groups. Generally, according to Korean curriculum, it is difficult to conduct activities related to interpreting the result of comparison of two groups without learning about sampling. However, the Chinese curriculum put the study of sampling in the beginning, which is used in performing such tasks by considering the variability due to sampling.

The next discussion is about experiment, which is not belonged to the secondary school textbook contents in Korea. All the statistics activities seem to

be built on the given data or students' observational study.

Lastly, the knowledge regarding to association can only be found in the new national curriculum of Korea, and the published textbooks employed in this paper do not involve this part.

In China, the acquirement of the properties of sampling is required in the first year of middle school, thus as addressed in the Figure 15, middle school students are supposed to "acknowledge that a sample may not be representative of the larger population" in the beginning of learning the statistics investigation in 7th grade. Figure 20 shows an exercise in 8th grade: Exercise 2 with a given line graph of scores from two shooters. The question of the exercise is that which person's score has the larger variance. Through this exercise, students' ability of quantifying variability between two groups is tested. Considering the exercise of 7th grade in Figure 18 as a foundation, this practice including a representative value of two groups with different conditions can be seen as the deepening study of "comparing data of different groups in displays".

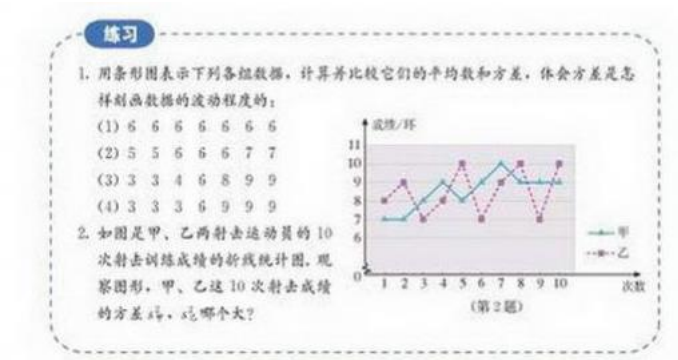


Figure 20 Exercise 2 on page 126 of PEP 8th grade mathematics textbook

Furthermore, Chinese middle school students are expected to be aware of the "distinction between observational study and experiment" in 9th grade before they start to use frequency to estimate probability through numerous repeated experiments.

Lastly, the definition of association is not given to students until they go to high schools, neither are any of the properties of association presented in the middle school textbook.

3.5 Nature of Variability (Sampling variability)

The knowledge with respect to sampling and sampling variability is taught in high school in Korea.

Figure 15 displays the evidence of description on Chinese textbook about the sampling variability, that a sample may not be representative of the larger population if the method of selecting the sample is inappropriate and furthermore, it will affect the accuracy of estimating the population.

3.6 Focus on Variability (Variability within a group and variability between groups; Covariability)

Covariability is related to covariance and correlation. On the basis of the new Korean curriculum, scatter plot and the informal concept of correlation are taught in middle school. No further knowledge related to correlation (such as correlation

coefficient, linear regression, joint distribution, etc.) will be introduced in high school curriculum in Korea. In China, the concept of correlation does not appear in middle school. However, based on PEP textbooks, correlation will be taught formally together with linear regression in the second year of high school.

4. Summary of the Analysis Based on GAISE Framework

In this section, the checklist based on GAISE (Franklin, 2005) framework is to check whether each of the components is included in the middle school statistics education contents, all of the national curricula, textbooks (both countries' textbooks utilized in this chapter are from the consistent publishers introduced in the former chapters). Information from in-service teachers, teacher's teaching manual and researches in two countries are also taken into consideration.

Besides, it should be noted that the classification of the three levels suggested by GAISE (Franklin, 2005) is not strictly paralleling with school grade of any country, the chance that some contents in Level B are included in other school levels is high, thus a cross mark in this checklist does not mean absent in the national statistics education, but could be taught in other educational levels, and it will be noted. The comparison results of Korean and Chinese statistics curriculum based on the checklist made from GAISE (Franklin, 2005) framework is shown in Table 22.

Table 22 Comparison Results of Middle School Statistics Education Contents in Korea and China

Component	Middle School Level	Korea	China
I. Formulate Question	● Is formulating questions for statistical problems taught?	×	√ (7th grade)
	● Are questions extended to a larger scale than the class?	×	√ (7th grade)
II. Collect Data	● Are sample surveys introduced? Do the students begin to use random selection?	×(12th grade)	√ (7th grade)
	● Is the comparative experiment taught?	×	×
III. Analyze Data	● Are measures of spread within a group taught?	√ (9th grade)	√ (8th grade)
	● Is comparing two groups in tables and charts taught?	√ (7th grade)	√ (7th grade)
	● Is the knowledge of sampling error introduced?	×(12th grade)	√ (7th grade)
	● Is the measure of association taught?	√ (9th grade)	×(11th grade)
IV. Interpret Results	● Is the relationship between sample and population explained?	×(12th grade) √ (9th grade)	√ (7th grade) √ (8th grade))
	● Is the difference between two groups with different conditions introduced?	×	√ (9th grade)
	● Are observational study and experiment introduced?	√ (9th grade)	×(11th grade)
	● Are the strength and direction of association taught?	√ (9th grade)	×(11th grade)
	● Is interpretation of models for association required?	√ (9th grade)	×(11th grade)
	● Is the distinction between association and cause and effect introduced?		

Nature of Variability	● Is sampling variability taught?	×(12th grade)	√(7th grade)
Focus on Variability	● Are variability within a group and variability between groups taught?	√(7th grade)	√(7th grade)
	● Is any knowledge related to covariance and correlation taught?	√	×(11th grade)

* The mark " √" means the component is found in the middle school curriculum or textbooks, "×" means the component is not found in the middle school curriculum or textbooks and the "()" followed behind means the component is found in other educational levels.

For most middle students in China and some in Korea, students begin to pose their own questions of interest in 7th grade, and also in this time, some statistical questions out of the classroom are raised up. As a matter of fact, neither the Korean national curriculum nor the textbooks this paper referred to have explicitly addressed the knowledge about formulation of question. In China, according to the textbook published by PEP, the middle school statistics study begins with a chapter named "Statistics investigation", where students start to put forward questions with population in a larger scale than their own classrooms. At first they are told how to formulate an appropriate question. To get prepared for the formulating their own questions, there are some exercises that lead them to choose the appropriate questions.

The "Collect Data" segment (the third row in Table 22) shows an obvious difference between two countries' statistics education contents in middle school. The knowledge on complete survey and sampling survey are clearly required by

the Chinese curriculum and textbook as the methods of data collection, whereas in Korea the formal study of sampling is not provided to students in national curriculum or textbook.

The process of data analysis contains most of the central knowledge in both countries' statistics education contents, and the first two components: "measures of spread within a group" and "comparing two groups in tables and charts" in the framework are both included in Korean and Chinese middle school textbooks. However the other components in the "Analyze Data" in Table 22 have showed obvious distinction in two countries. The knowledge related to sampling is totally missing in the Korean curriculum and hardly included in the textbooks, while correlation is added in the new national curriculum. On the contrary, sampling is the beginning of statistics study in Chinese middle school textbook, while the knowledge of correlation is only taught in high school.

In general, the interpretation of results in statistics investigation process seem to be less important than data analysis in middle schools of Korea and China, which is also noticeable in the flowcharts of statistics knowledge structure in the previous chapter. The comparison results has revealed the fact that nearly half of the components in the "Interpret Data" are missing in Korean and Chinese statistical education contents.

Lastly, the components of 'Nature of Variability' and 'Focus on Variability' are partly involved in Korean and Chinese curriculum and textbook. The involving of correlation in Korean middle school enables students get to know the variability

between two variables, and in China the properties of sampling and the relationship between sample and population include the learning of variability.

5. Supplementary Information

In this section, the supplementary information regarding the education environment in two countries is provided and discussed.

It is well known that Korean students are skilled at the numeral calculation. However, according to the PISA test score in the statistics part, they are not able to perform as excellent as they do in the other parts of mathematics. The information supplied by two experienced in-service teachers in Korea (Miss Lee, a secondary math teacher of School A; Miss Lee, a middle school math teacher of School B) indicated that under many circumstances, students are confused by meanings of different representative values and have difficulties to choose the proper method to quantify variability by the given data, even though they have remembered the formulations clearly. To improve the education environment and encourage the freedom of study in middle school, the Korean government urges a program called 'doing math', which allows students in 7th grade to experience the "Autonomic Semester System (자율학기제)". During the autonomic semester, students are mandated to conduct their study without being tested, and this could be seen as one of the most significant breakthroughs in Korean middle school education system. Another important fact is that the "Korea statistical training institute (통계교육원)" has developed various programs for teachers to carry on

in their class. Thus not only the students can study without the pressure frequent quizzes or tests, but also the teachers have more choices and opportunities to infuse diverse range of didactical activities into their classes.

With respect to the situation in China, the training of drawing graphs, making tables and calculating representative values in middle schools is intense similar to Korea, and such situation is confirmed by an experienced middle school teacher in Beijing (Miss Liu, a middle school math teacher in school C). Consequently the problems caused by the over emphasis on arithmetic training and lack of focus on application exist in Chinese middle school classrooms as well. He (2017) conducted a research using questionnaire survey, classroom observation, interviews and other methods to investigate middle school students' performance on statistics in China. He found that most teachers only pay attention to the formulas and calculation, which causes students' neglect of fully understanding of the data analysis methods. Thus students were having difficulties in analyzing the data by choosing the appropriate methods. While as mentioned before, the reform of national curriculum in China keeps contributing to improvements in practice. Zhao (2016) found most teachers thought the "Statistics and Probability" section in the new curriculum is more logical and structured than before. Besides, under the guidance of the reformed national curriculum, most teachers have gradually changed their ways of teaching and tried to achieve students' self-exploration, cooperation, communication and practice. Meanwhile the students thought highly of the new textbook, too.

VI. Conclusion and Discussion

1. Summary of Research Results

According to GAISE (Franklin, 2005), with the understanding of statistical concepts at B level, students should start to realize that the data analysis is a statistics investigation process, consisting of formulation of questions by themselves, collection of appropriate data from censuses, sample surveys, and comparative experiments, analysis of data utilizing graphs for displaying data and representative values for measuring the central tendency and dispersion, and interpretation of results including the inferential statistics, using a sample to estimate the population.

Based on the suggestion from GAISE (Franklin, 2005), the statistics education situations in Korea and China are compared with a checklist and analyzed in details. Thus, three conclusions are drawn from the study in this chapter by the framework in GAISE (Franklin, 2005) served as the criteria.

(1) Korean middle school students seem to have many obstacles to experience and study the complete statistics investigation process, for the missing of formulating question and collecting data with methods such as sampling and experiment, as well as the inferential statistics when interpreting results.

(2) Chinese secondary students are not able to analyze two variables association until high school, nonetheless to say the models for association, which makes data analysis and interpretation quite flat as the middle school level, and also might generate burden for high school students as they need to absorb the new

concepts and properties of association without a foundation building in advance.

(3) With respect to the checked components in the framework (Table 22), there are also problems existing in both countries. It is stressed in the previous chapter that Korean students are skilled at the numeral calculation, while they do not perform well in statistics. The information supplied by in-service teachers indicated that students are confused by meanings of different representative values and have difficulties to choose the proper method to quantify variability by the given data. Such problem also exits in Chinese middle schools: only paying attention to the formulas and calculation causes students' neglect of fully understanding the data analysis methods and difficulties in analyzing the data by choosing the appropriate methods.

2. Discussions on Middle School Statistics Curriculum and Textbook in Korea and China

First, in Korean new national curriculum, some part of the statistics education seems inconsistent with the general objectives and key competencies (Table 3), whereas the Chinese curriculum generally shows the accordance. It might due to the chapter named 'curriculum contents' in the Chinese curriculum, which helps to provide a more explicit guidance for the statistics education and makes the outline of general objectives less ambiguous.

Second, aligned with the national curriculum, Korean new textbook contains the content of scatter plot and correlation, which can help analyze and interpret

some data in statistical investigation process, while it is excluded in Chinese middle school curriculum and textbook. In China, the scatter plot and correlation are first taught in high school.

Last, by the framework in GAISE (Franklin, 2005), statistics education in both Korea and China appear to lack of components in the investigative process. In Korea, the beginning of the process, formulation of questions is not found on national curriculum or textbooks in middle school. The collection of data is also neglected without the requirement of the knowledge of sampling, one of the most important and basic data collection methods. While in Chinese statistic education, the first time to bring in correlation is in the second year of high school, thus the middle school students are not able to analyze data or interpret results in respect of variables' association. Besides, exclusion of comparative experiment and think lightly of experiment are the common feature different from education in western countries. On the contrary to the application, unsurprisingly, the pure calculation catches much attention in both countries.

Thus, instead of simply emphasizing on the acquirement of formula and pure calculation, the curriculum, textbook and teachers in practice need to be further enhance the aim of doing such calculation, such as "quantify variability", "note the difference", etc.

Reference

Mark Bray, Bob Adamson, Mark Mason. (2014) *Comparative education research: approaches and methods.* Hong Kong, China: Comparative Education Research Centre.

Christine Franklin, Gary Kader, Denise Mewborn, Jerry Moreno, Roxy Peck, Mike Perry, Richard Scheaffer (2005). *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report.* American Statistical Association Alexandria, VA 22314.

Mathematics Curriculum No. 2015-74 [Separate volume 8]. Ministry of Education of Republic of Korea.

Mathematics Curriculum Notification No. 2011-361 [Separate volume 8]. Ministry of Education, Science and Technology of Republic of Korea.

(Compulsory Education) Mathematics Curriculum Standards (2011 version). Ministry of Education of the People's Republic of China. Beijing Normal University Publishing Group. Beijing Normal University Publisher.

Halls, W.D. (ed.) (1990) *Comparative education. Contemporary issues and trends*. London: Jessica Kingsley Publishers.

Margaret WU (2006), *A Comparison of Mathematics Performance Between East and West: What PISA and TIMSS Can Tell Us.* Mathematics Education in Different Cultural Traditions-A Comparative Study of East Asia and the West: The 13th ICMI Study. doi:10.1007/0-387-29723-5_1, Chapter 2-6, page 239-259.

Yoon Sangjoon, Lee Ahran, Kwon Oh Nam. (2019). *Analysis on the relationship between core competencies and mathematical competencies and the tasks for mathematical competencies: A case of high school 'Mathematics' textbooks according to 2015 revised mathematics curriculum.* A-수학교육, 2019, Vol.58(1), p.55, ISSN: 1225-1380.

Nam-Jin Paik (Ewha Womans University). (2014). *Review of statements of achievement standards in subject curriculum: Focusing on the national science curriculum of Republic of Korea and the U. S.* The Journal of Curriculum Studies 2014/6, Vol. 32, No. 2, pp. 101~131.

Hongyan Shi. (2013) *A Comparative Study on High School Mathematics Curriculum of the Netherlands and China.* Northwest Normal University.

陈侠(Chen Xia). (1989). *课程论*. 人民教育出版社.

吴也显 (Wu Yexian). (1984). *教育学*. 人民教育出版社.

王正胜(Wang Zhengsheng). (2011). *复合、融合与整合：国内高校英语专业课程设置研究*[J].高等教育研究. 2011(1):84-88.

杨慧娟 (Yang Huijuan). (2010). 西南大学 数学与统计学院，青岛大学 师范学院数学系. *数学教育价值的重新审视——姜伯驹先生谈数学课程改革*. 数学教育报. 第19卷第四期 2010年8月.

Karen C. Fuson and Yeping Li. (2014) *Learning Paths and Learning Supports for Conceptual Addition and Subtraction in the US Common Core State Standards and in the Chinese Standards*. Y. Li, G. Lappan (eds.), Mathematics Curriculum in School Education, Advances in Mathematics Education, DOI 10.1007/978-94-007-

7560-2_25, Springer Science+Business Media Dordrecht 2014

Hak Ping Tam, Ngai-YingWong, Chi-Chung Lam, Yunpeng Ma, Lije Lu, and Yu-Jen Lu. (2014) *Decision making in the Mathematics Curricula among the Chinese Mainland, Honkong, and Taiwan*, Mathematics Curriculum in School Education, Advances in Mathematics Education. DOI 10.1007/978-94-007-7560-2_6

Hugh Burkhardt. (2014) *Curriculum Design and Systemic Change.* Shell Centre for Mathematical Education, University of Nottingham, Nottingham, NG8 1BB, UK./H.

赵薛霞 (Zhao Xuexia). (2016). *初中概率与统计的教学研究*, *Junior high school teaching and research of Statistics and probability*. 内蒙古师范大学硕士专业学位论文. G633.6.

Huo Yujia. (2011). *Comparative Study on the Content of "Statistics and Probability" in Chinese and American Primary Mathematics——In the Example of Textbooks for Primary School of PEP and California Edition*. Master Degree Paper of Chongqing Normal University.

PARK Kyungmee and LEUNG Koon Shing Frederick, (2006), *A Comparative Study of the Mathematics Textbooks of China, England, Japan, Korea, and the United States*, 10.1007/0-387-29723-5_14.

He Yi. (2017). *A Teaching Research of Statistics and Probability of Developing Students' Concept of Data Analysis in Junior High School*. A Thesis Submitted to Chongqing Normal University in Partial Fulfillment of the Requirements for the Degree of Master. Chongqing Normal University.

Appendix

1. Korean National Mathematics Curriculum

1.1 The general achievement objectives in Korean national mathematics curriculum ('15) (Mathematics Curriculum. Notification No. 2015-74. [Separate volume 8]. Page 9):

(1) Through the experience of mathematical observation, analysis, organization and expression about society and natural phenomena, understand mathematical concepts, theories, rules and the relation between them, and acquire mathematical skills.

(2) Through the mathematical inference and communication, based on creative and comprehensive thinking and information processing ability, understand the society and natural phenomena mathematically, and solve problems reasonably and creatively.

(3) Keep the interest and confidence with mathematics, recognize the value of mathematics, and as a mathematics learner, cultivate the desirable attitude and practice ability.

1.2 The general achievement objectives in Korean national mathematics curriculum ('09) (Mathematics Curriculum. Notification No. 2011-361. [Separate volume 8]. Page 3):

a. Through the experience of mathematical observation, analysis, organization and expression about surroundings or society and natural phenomena, cultivate the

competency of understanding the basic mathematical functions and concepts, theories, rule, and the relations between them.

b. With the cultivation of mathematical thinking and communicating skills, cultivate the competency of reasonably and creatively solving problems which are obtained from surroundings or society and natural mathematical phenomenon.

c. Keep the attention and interest in mathematics, understand the value of mathematics, and as a mathematics learner, cultivate the desirable character and attitude.

1.3 The achievement standards in Korean national mathematics curriculum ('15) – Statistics at Middle School Level (Mathematics Curriculum. No. 2015-74 [Separate volume 8]. Page 39. (5) Probability and Statistics):

(1) Data Organization and Analysis

[9수05-01] Utilizing stems-and-leaf plot, frequency distribution table, histogram, and frequency distribution polygon to represent and analyze data.

[9수05-02] Calculate the relative frequency and utilize graphs to represent it, and understand the distribution of relative frequency.

[9수05-03] Use engineering tools to collect real-life data, organize the data with tables or graphs and analyze them.

(2) Probability and Its Basic Properties

[9수05-04] Obtain the number of cases.

[9수05-05] Understand the concept and basic properties of probability, and

calculate the probability.

(3) Representative Value and Scatter Plot

[9수05-06] Understand the meanings of median, mode, and mean, and acquire the calculation of them.

[9수05-07] Understand the meanings of variance and standard deviation, and acquire the calculation of them.

(4) Correlation

[9수05-08] Represent the data in scatter plot, and use this to describe the correlation.

1.4 The achievement standards in Korean national mathematics curriculum ('09) – Statistics at Middle School Level (Mathematics Curriculum. No. 2011-361. [Separate volume 8]. Page 36. (4) Probability and statistics):

a. Achievement standards in different school years

Understand steam-and-leaf plot, frequency distribution table, histogram, frequency polygon and relative frequency, calculate probability, as well as representative value and measure of dispersion.

b. Achievement standards in different subjects

① Understand steam-and-leaf plot, frequency distribution table, histogram, frequency polygon and relative frequency. ② Understand the meaning of probability, and acquire the calculation of probabilities. ③Understand the meaning of median, mode, average, dispersion, standard deviation, and acquire the

calculation of them.

c. Achievement standards of learning content

(1) Frequency distribution and graphs

①Understand and analyze of steam-and-leaf plot, frequency distribution table, histogram, frequency polygon. ② Calculate the average of the data whose frequency distribution table is given. ③ Calculate relative frequency and illustrate it with graph, and understand the distribution of relative frequency.

(2) Probability and its basic properties

① Acquire the calculation of number of cases. ② Understand the meaning of probability and its basic properties. ③ Acquire the calculation of probability.

(3) Representative value and measure of dispersion

① Understand the meaning of median, mode and average and acquire the calculation. ② Understand the meaning of dispersion and standard deviation and acquire the calculation.

1.5 The achievement standards in Korean national mathematics curriculum ('15) – Statistics at High School Level (Mathematics Curriculum. No. 2015-74 [Separate volume 8]. Page 98. (3) Statistics 2. Statistical Inference):

[12PS03-05] Understand the meaning of population and sample and the principle of sampling.

[12PS03-06] Understand and be able to explain the relationship between sample mean and population mean.

[12PS03-07] Estimate the population mean and interpret the results.

2. Chinese National Mathematics Curriculum

2.1 The general achievement objectives in Chinese mathematics curriculum 2011 ((Compulsory Education) Mathematics Curriculum Standards (2011 version). Page 8. 1. General Objectives):

(1) Obtain the basic mathematical knowledge, skills, thinking and activity experience which are necessary for socialization and further development.

(2) Recognize the connection between mathematical knowledge, mathematics and other subjects, mathematics and life, and think in a mathematical way, enhance the ability to discover and raise problems, as well as analyze and solve problems.

(3) Appreciate the value of mathematics, uplift the interest of learning mathematics, increase the confidence of learn mathematics well, cultivate the good learning habit, and own the primary sensibility of innovation and scientism.

2.2 The Achievement Contents in Chinese national mathematics curriculum 2011 – Statistics at Middle School Level ((Compulsory Education) Mathematics Curriculum Standards (2011 version). Page 19. 3. Statistics and Probability):

(1) Classify things or data based on the given criterion or the criterion selected by students, and perceive the relation between classification and classification criteria.

(2) Go through the simple process of data collection and organization, recognize investigation, measurement and other simple methods of collecting data, and be

able to present the result of data organization in one's own way (literature, graph, table, etc.).

(3) Through the simple analysis of data, understand how to use data for expression and communication, and recognize the information contained in data.

The contents above embody an outline of the statistical education in middle school and could be seen as a qualified guidance for textbook writing, teaching practice or other educational activities.

2.3 The Achievement Standards in Chinese national mathematics curriculum 2011 – Statistics at Middle School Level ((Compulsory Education) Mathematics Curriculum Standards (2011 version). Page 39-40 3.Statistics and Probability):

(I) Sampling action and data analysis

(1) Take part in the activities of collecting, organizing, describing and analyzing data, know the process of data processing, and be capable of using calculator to process the relatively complicated data.

(2) Comprehend the necessity of sampling, and get to know simple random sampling through examples.

(3) Be able to draw sector diagram and use statistical diagram to describe data in a visualized and effective way.

(4) Understand the meaning of mean, be able to calculate median, mode, weighted mean, and know they are the description of the central tendency of data.

(5) Comprehend the meaning of depicting the dispersion degree of data, and be

able to calculate the variance of some simple data.

(6) Get to know the meaning of frequency and frequency distribution through examples, be able to draw frequency histogram and use it to explain the information contained in data.

(7) Comprehend the relation between sample and population, and know that the mean and variance of population can be estimated by the mean and variance of sample.

(8) Be capable of explaining the statistical result, making simple judgment and prediction based on the result, and communicating with others.

(9) With table, line chart, tendency chart, etc. perceive the variation tendency of random phenomena.

(II) Event probability

(1) Be able to list all the possible outcomes of simple random events and given events by means of making lists, drawing tree diagrams and so on, and know event probability.

(2) Know that through substantive repeated trials, probability can be estimated by frequency

초 록

본 연구는 한국과 중국의 중학교 통계 교육을 비교하고, 국가교육과정 및 교과서의 유사점과 차이점을 요약하며, 중학교 교육 내용 영역에 포함된 통계적 조사 과정을 탐색하기 위한 목적으로 실시되었다. 이를 위해 Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report에서 제시하는 분석틀을 비교 기준으로 도입하였으며, 보다 포괄적인 관점에서 도출된 결론을 얻고자 양국의 국가교육과정 및 교과서와 더불어, 현직 교사 및 교육 연구자들이 제공한 정보를 바탕으로 분석을 시행하였다. 최종적으로, 일련의 비교 분석을 통해 한국과 중국의 통계 교육에 대한 포괄적인 결론과 제언을 제시하였다.

본 논문에서는 국가교육과정 및 교육과정을 바탕으로 만들어진 복수의 교과서를 비교하기 위해 GAISE를 분석틀로 한 질적 연구를 실시하였으며, 이를 통해 중학교 통계 국가교육과정 및 교과서에 대한 다양한 결론을 도출하였다. 첫째, 한국의 개정교육과정과 교과서의 경우 일반적인 목적과 핵심역량이 서로 상이한 측면을 포함하고 있는 반면, 중국의 교육과정과 교과서는 내용 영역이 보다 일관성을 갖추고 있었다. 둘째, 한국 개정교육과정의 교과서가 이전 교육과정의 교과서에 비해 보다 완성도 높은 통계적 조사과정을 포함하고 있긴 했지만, 그럼에도 중국의 교과서와 비교하였을 때 상당수의 내용이 여전히 단순계산에 치우쳐 있었다. 셋째, GAISE를 분석틀로 바라보았을 때, 한국과 중국의 통계교육 모두 통계적 조사과정의 중요한 요소들이 결핍되어 있었고, 단순계산 문제에 지나치게 치중하고 있었다. 이와 같은 연구 결과가 한국과 중국의 교육과정 개정 및 교과서 집필과 관련하여 통계 교육의 발전에 기여할 수 있을 것으로 기대한다.

주요어: 비교 연구, 통계교육, 국가교육과정, 중학교 교과서, GAISE
학 번: 2017-26086